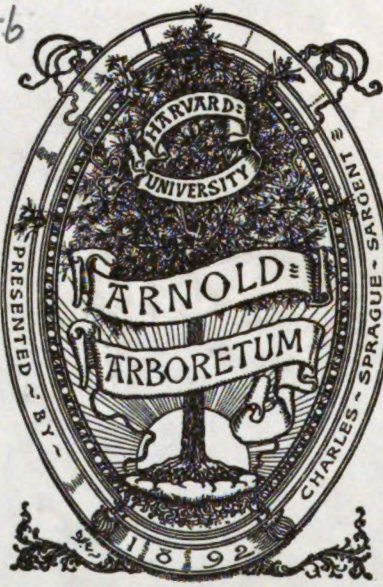
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# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES

## VOLUME III, 1913



PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST AND SEPTEMBER WHEN MONTHLY,

BY THE

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VOL. III. JANUARY 19, 1913. No. 2.

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# Journal of the Washington Academy of Sciences

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# JOURNAL

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# WASHINGTON ACADEMY OF SCIENCES

Vol. III, JANUARY 19, 1913 No. 2

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PHYSICS.—*A mechanical differential telethermograph and some of its applications.* LYMAN J. BRIGGS, Bureau of Plant Industry.

This instrument consists essentially of two independent Bourdon spring systems, each hollow spring communicating with a copper bulb by means of a copper capillary. Each system is completely filled under pressure with a liquid having a high thermal expansion coefficient. These two systems are mounted as shown in the illustration in such a manner that the free ends of the springs move in the same plane and in opposite directions when the two systems undergo the same change in temperature. The free ends of the two Bourdon springs are connected in the plane of movement by a double link, the two members of which are approximately parallel and normal respectively to the paths traversed by the ends of the springs. The normal link is connected at its approximate center to a second link which communicates with the pen mechanism.

When the two systems undergo a simultaneous change in temperature, the free ends of the springs, in expanding or contracting, rotate about the center of the connecting link without producing any translation of this point. No change occurs, therefore, in the position of the recording pen on the drum. When, however, a differential change in the temperature of the two systems occurs, a greater movement is produced in the free end of one Bourdon spring than in the other, and a corresponding movement of the pen-arm takes place. The instrument is thus designed to record differences in the temperature of the two systems, independent of the absolute temperature.

While the Bourdon springs necessarily expand in response to an increase in their own temperature independently of that of

the bulbs, such changes do not affect the reading of the instrument, providing the springs do not differ substantially in temperature at any time during this change. To secure this equality in temperature of the two springs as nearly as possible, the instrument is provided with a metal cover blackened inside, and the interior is given an open construction. The two copper capillaries can also be kept at the same temperature for the greater part of their length. The differential temperature

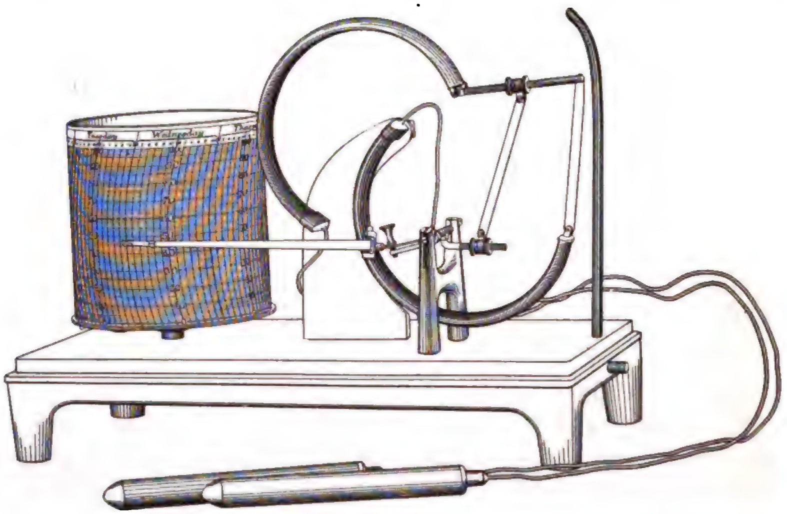

**Fig. 1. A mechanical differential telethermograph. Capillary tubes much longer than those shown in the illustration may be used.**

recorded is, therefore, substantially that represented by the difference in temperature of the two bulbs.

## APPLICATIONS

Two applications of this instrument have been made during the past year in connection with investigations in bio-physics.

*Recording the depression in temperature of the wet-bulb thermometer.* One use of the instrument consists in recording changes in the depression in temperature of the wet-bulb thermometer. For this purpose the apparatus is placed in a ventilated instrument shelter. One bulb is covered with muslin and kept con-

tinually moistened by allowing water to drop upon it very slowly from a reservoir, while the other bulb assumes the temperature of the shelter. In this way a continuous graph is obtained of the depression in temperature produced by the wet covering, independently of changes in the air temperature. By using this record in connection with a simultaneous record obtained with an air thermograph, the humidity at any time can be calculated from standard psychrometric tables.

*Recording changes in intensity of solar and sky radiation.* If one bulb of the instrument is blackened and exposed in a glass jacket to radiation from the sun and sky, while the other bulb is kept at air temperature, the differential temperature of the two bulbs due to the radiation received is recorded. The instrument in this form gives a continuous record of changes in the intensity of the radiant energy received, altho the interpretation of this record in absolute units is of course dependent upon calibration with an absolute instrument. The types of sunshine recorders ordinarily employed give no indication of the magnitude of the changes in the radiant energy, but indicate simply whether the radiation exceeds a certain intensity.

The development of the instrument with a view to providing a continuous quantitative record of the intensity of the radiation received at the earth's surface is now in progress.

PHYSICS.—*Media of high refraction for refractive index determinations with the microscope; also a set of permanent standard media of lower refraction.* H. E. MERWIN, Geophysical Laboratory. Communicated by Arthur L. Day.

A number of experimental studies have been carried on for the purpose of extending the conditions under which determinations of refractive index by means of the microscope can be made. Such determinations require immersion media of standard refractive index. Various immersion liquids have been in use for the determination of refractive indices over the interval 1.33 to 1.80; mixtures of amorphous sulfur and selenium have been found useful over the range (for sodium light) 2.1 to 2.4. The immersion media to be described have been devised to fill the gap 1.80

to 2.10, and to extend the series beyond $2.4_{Na}$, or in special cases, particularly when a refractometer is not at hand for standardizing the liquids, take the place of media hitherto used. For the latter purpose solids have been found which may be mixed in given proportions by weight to produce permanent standard media. These are either vitreous (more or less rigid) or liquid (fluid).

Altho differences in refractive index as small as 0.001 can be detected under the microscope by either the method of oblique, or of central illumination, it is seldom that in determinative mineralogical work results closer than 0.01 are of practical use owing to the complex character of most minerals. For this reason many details concerning the preparation and use of these

TABLE 1

| $CHI_3$ | $SnI_4$ | $AsI_3$ | $SbI_3$ | S | $n_{na}$ at 20° |
|---|---|---|---|---|---|
| | | | 12 | | 1.764 |
| | 25 | | | | 1.783 |
| | 25 | | 12 | | 1.806 |
| | 30 | | | 6 | 1.820 |
| | 27 | | 7 | | 1.826 |
| 40 | 27 | 16 | | | 1.842 |
| | 31 | 14 | 8 | 10 | 1.853 |
| 35 | 31 | 16 | 8 | 10 | 1.868 |

media are not included here but may be found in the complete record of the work when published.

*Liquids, n = 1.74 to 1.87.* In 100 parts of methylene iodide at 20° the number of parts of the various substances indicated in the table (1) can be dissolved, forming saturated solutions having the permanent standard refractive indices specified.

When ready for use, the liquids can be mixed by means of a dropper to give intermediate refractions. Commercial iodoform ($CHI_3$) powder is not suitable, but crystals from a solution of the powder in ether may be used, or the crystallized product may be bought. A fragment of tin in the liquids containing $SnI_4$ will prevent discoloration.

*Liquids, n = 1.74 to 2.28.* Near its boiling point methylene

iodide slowly dissolves precipitated arsenic trisulphide, forming an orange-colored liquid. After some days crystals separate, but while fresh—or after the heating of an old preparation which is not discolored—the solution can be used for accurately matching the refractive index of a substance, and then standardized by means of a goniometer[1] or a spectrometer and prism.

*Resin-like substances*, $n = 1.68$ *to* $2.10$. Piperine, one of the least expensive of the alkaloids, can be obtained in very pure, straw-colored crystals. When melted it dissolves the tri-iodides of arsenic and antimony very freely. The solutions are fluid at slightly above 100°, and when cold are resin-like. The red color of the iodides is present in the solution. The color, however, is of such a character that determinations of refractive index made in the solutions in white light are almost as accurate as those made in sodium light. If less than 7 per cent of the iodides is present this solution should be examined thru a film of a 7 per cent solution. A solution containing 3 parts of antimony iodide to 1 part of arsenic iodide with varying proportions of piperine is easier to manipulate than one containing either iodide alone. The diagram, figure 1, gives the necessary data concerning composition and refractive index for sodium light. In preparing, the constituents, in powder of about 1 mm. grain, should be weighed out, and then fused *over*—not *in*—a low flame. Three-inch test tubes are suitable. Stirring with a glass rod is essential. A little of this material is placed on a glass slip with some of the powder to be examined, it is then warmed and pressed thin under a cover-glass. For use with the more highly refracting materials the powder must be very fine to permit a very thin film to be made. An artificial light is advantageous for observing the deeply colored films. The iodides should be examined under the microscope for mechanical impurities.

*Mixtures of amorphous sulfur and arsenic trisulfide*, $n = 2.1$ *to* $2.6$. These mixtures are much lighter colored than corresponding ones of sulfur and selenium, but they are less easily standardized and manipulated. They should be used only in cases requiring greater transparency than the sulfur-selenium mixtures. They

[1] See Am. Jl. Sci. **34**: 46. 1912.

must be standardized by means of a prism which is ground or moulded. About equal parts of dried precipitated $As_2S_3$ and

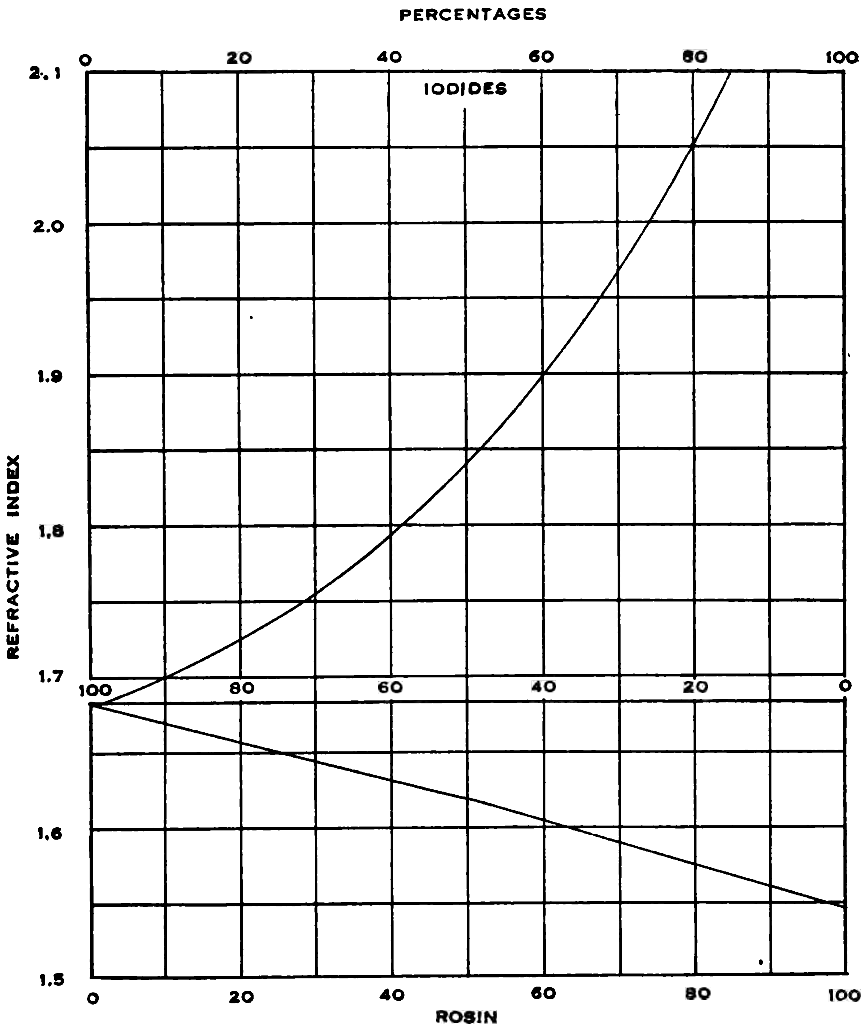


Fig. 1. Composition and refractive index

flowers of sulfur are intimately mixed by grinding moist with alcohol. The mixture when dry is strongly heated in a test tube which is not more than one-third full. A part of the sulfur will

boil away. The mixture remaining can be powdered and heated with either sulfur or $As_2S_3$ to produce a mixture having the desired refractive index.

*Permanent standard resinous media, n = 1.546 to 1.682.* Any proportions of piperine and rosin form a homogeneous fusion which cools to a transparent, resinous mass. Figure 1 shows the refractive indices of various mixtures. On account of the strong dispersion of piperine the refractive indices of minerals apparently matched with those of mixtures rich in this constituent are 0.005 to 0.01 too low. To correct the error a screen made of a thin film of 7 per cent antimony iodide and 93 per cent piperine should be used over the eye-piece. Any amber-colored rosin in lumps is suitable.

TABLE 2

| CAMPHOR | THYMOL | MIXTURE OF 2 PARTS THYMOL, 1 PART CAMPHOR | SALOL | MIXTURE OF 6 PARTS SALOL, 4 PARTS CAMPHOR | ALPHA-NAPTHYLAMINE | $n$ |
|---|---|---|---|---|---|---|
| 35 | 65 | | | | | 1.487 |
| 67 | 33 | | | | | 1.505 |
| | | 100 | 0 | | | 1.505 |
| | | 60 | 40 | | | 1.536 |
| | | | | 100 | 0 | 1.536 |
| | | | | 50 | 50 | 1.610 |
| | | | 23 | 77 | | 1.610 |
| | | | 0 | 100 | | 1.683 |

*Permanent standard resinous media, n = 1.510 to 1.546.* This series is prepared from rosin and camphor. Each per cent of camphor present lowers the refractive index 0.0007. Not more than 40 per cent of camphor may be present without causing crystallization. The rosin is weighed out and melted slowly, when it is partly cooled but not yet hard, the camphor (well crushed) is stirred in. Heat is then applied gently and stirring is continued till the camphor is dissolved. Camphor does not volatilize appreciably from the cold mixtures if they are kept in stoppered containers.

*Permanent standard fluids, n = 1.487 to 1.683.* Several organic solids have been found which form eutectic mixtures melting much below ordinary temperatures. By plotting on cross-section

paper and connecting by straight lines each pair of points in table 2 the composition and refractive index of a complete series of fluids will be represented. Errors in $n$ will not exceed $\pm$ 0.003 if fairly pure crystalline substances are used. Some of the fluids having $n$ between 1.61 and 1.683 may crystallize after standing, but slight warming will restore their fluidity. Other materials under investigation give permanent fluids over much of this range. Where three constituents are specified in the table two of them in fixed proportions are used to form one variable constituent.

ELECTROCHEMISTRY.—*The silver voltameter. III.* E. B. Rosa, G. W. Vinal and A. S. McDaniel. To appear in the Bulletin of the Bureau of Standards.

The second series of quantitative experiments began in December, 1909, after several months spent in the qualitative work described in Part II. As a result of the preceding work the authors had discarded the filter paper voltameter as an instrument of precision and turned their attention to the problems related to the porous cup form and the purification and testing of the electrolyte. The apparatus and methods employed were similar to those previously described.

During this period of the work the small porous cup voltameter was found to be the most convenient and reliable form to use as a standard. With the purest salt available the deposits were adherent and white, always non-striated, and crystalline as seen under the microscope. As a test of the reproducibility of this small porous cup form, fifty-four deposits made in pairs (except two sets of three each) in which the electrolyte and other conditions were as nearly identical as possible in the two cups of each pair were tabulated. The average deviation of each value from the mean of each group (of 2 or 3 cups) was found to be 1 part in 100,000. That is, when the variations in the electrolyte and the measurement of current and time are eliminated so that it is simply a question of how nearly two similar voltameters agree with one another and the variations are produced by loss of silver in washing the deposit, fluctuation in moisture or impurity in the deposit and the errors in weighing the cups the average

deviation of individual values from the mean of 2 or 3 cups is only 0.001 per cent.

Comparison of the large porous cup voltameter with the smaller size showed consistently a heavier deposit in the former by about 5 parts in 100,000 and the siphon form which required a very large volume of electrolyte gave a still greater excess. It was at length discovered that this excess of deposit in the larger sizes was roughly proportional to the volume of the electrolyte and the authors have called this the "volume effect." It seemed probable that this was due to traces of impurity which had not been eliminated from the electrolyte and led to an extended investigation of the purifying and testing of silver nitrate. As a result of this work, electrolyte was prepared which satisfied all the criteria for purity and brought the large sizes of voltameters into agreement with the small porous cup voltameter, thus justifying its previous use as a standard form. The effect of slight contamination of the electrolyte in this small size must have been almost negligible as the results obtained with it have been amply justified by the subsequent work. As the experiments progressed the "volume effect" was found to be a very useful indication of the purity of the electrolyte, revealing the presence of impurities too small in amount to visibly affect the crystalline structure of the silver deposit. It is not claimed that this phenomenon of heavier deposits in large voltameters is a new discovery, for it was observed in the work of Lord Rayleigh nearly thirty years ago and has been ascribed to various causes, but the authors do believe that its significance has not been appreciated before, nor the correct explanation for it given.

Using the mean of 44 of the most reliable determinations made in the small porous cup form of voltameter during the period December, 1909, to April, 1910, the authors have obtained as the value for the Weston Normal Cell at 20°C. on the present basis:

$$1.01827_5 \text{ volts.}$$

This is very close to the value recorded in the first series of measurements and is probably more reliable.

Several determinations were made in which two voltameters were maintained at 50°C. by external heating coils during the

passage of the current, for comparison with two similar voltameters at room temperature (about 20°C.). The results indicate that there is no temperature coefficient as Kohlrausch and Weber also have shown in a different way. It is believed that the reasons other observers have found increased deposits in voltameters at higher temperatures is because the chemical activity of impurities in their electrolyte would naturally increase with the rise in temperature.

Two gold dishes similar in design to the smaller platinum dishes previously used were purchased for comparison. By tabulating the differences in deposit between the gold and platinum cathodes in each case where no other differences in the voltameter existed it was found as a result of twenty-nine comparisons that the deposits in the gold dishes were lighter by 1.4 parts in 100,000 which may be regarded as indicating the substantial agreement of the two materials.

Some further work was done with the Poggendorff form but the results were not encouraging and hence attention was directed chiefly to the forms that had proved more reliable and the purification and testing of the electrolyte in anticipation of the coöperative work with the English, French and German National Laboratories which began in Washington April 1, 1910.

The most difficult problems connected with the preparation of silver nitrate for use in the voltameter are concerned with the exclusion or removal of reducing impurities and colloidal silver on the one hand and of uncombined acid and base on the other. The tests that have been developed for determining the acidity of the solution are for the purpose of determining the uncombined acid or base rather than the absolute hydrogen ion concentration.

The usual methods of testing the neutrality of salts do not apply to silver nitrate. Thus, toward litmus a silver nitrate solution will react alkaline even after the addition of 1 part in 100,000 of nitric acid and a similar solution will react acid toward methyl orange after the addition of alkali provided the silver is not completely precipitated. Other indicators also were tried. If the silver be precipitated from the silver nitrate solution by neutral KCl solution and the AgCl precipitate filtered off on asbestos

the filtrate will show a neutral reaction toward the various indicators if the original $AgNO_3$ contained no uncombined acid or base. By using iod-eosine as an indicator so little as 1 part in 1,000,000 of nitric acid (or alkali) added to the original $AgNO_3$ can be detected in the filtrate by titration with $\frac{N}{1000}$ $HNO_3$ or NaOH. The results have been expressed in terms of parts per million of the nitric acid.

For the detection of the more resistant forms of reducing impurities (principally cellulose hydrates from filter paper) and colloidal silver a titration test with $\frac{N}{1000}$ $KMnO_4$ solution has proved very valuable. The slightly acidified crystals of silver nitrate are fused as will be described for purifying the salt and dissolved in water to form a 66 per cent solution. Ten cubic centimeters of this solution is acidified by adding 1 cc. of concentrated nitric acid (free from nitrous acid) and the $\frac{N}{1000}$ potassium permanganate solution added in 0.5 cc. portions until the pink color persists for five minutes or more. The number of cubic centimeters thus required the authors have called the "permanganate number" of the silver nitrate. In test cases this has been found to be proportional to the amounts of oxycelluloses previously added to the silver nitrate and very minute traces can thus readily be detected. It is not claimed that the organic material is necessarily oxidized completely but nevertheless the method is much more sensitive than any method of direct combustion would prove under the circumstances as well as being more expeditious. By titrating these concentrated solutions of silver nitrate less than 0.001 per cent of colloidal silver may be detected, a result that is of particular value in showing when over fusion of the salt has occurred in its preparation.

The water used was twice distilled in block tin and kept in bottles of especially prepared resistant glass. Samples of it were frequently tested for its conductivity and alkalinity. These were, on the average, about $1.3 \times 10^{-6}$ reciprocal ohms and 0.6 parts in 1,000,000 respectively. The water in the stills was boiled by steam under pressure thereby avoiding the possibility of contamination by $CO_2$ which may greatly increase the deposit in the voltameter.

For purifying the silver nitrate for use in the voltameter it is convenient to start with the best c. p. salt obtainable from the manufacturing chemists. If this salt is repeatedly recrystallized from neutral solution the resulting product shows a tendency to become basic which under certain conditions gives rise to the volume effect in the voltameter. To avoid this condition it is necessary that the last mother liquor should be acid to the extent of from 0.1 to 1 per cent of the water present depending on the efficiency of the draining. In the present work a centrifuge has been employed and the crystallization carried out in porcelain, quartz and platinum vessels without any significant differences in the final product. It is best that the preliminary recrystallizations should be made from strongly acid solutions as this increases the yield of crystals owing to the less solubility of the $AgNO_3$ and decreases the number of crystallizations required to satisfy the permanganate test.

Salt yielding the same result in the voltameter has also been prepared by recrystallization from strongly acid solution and subsequent fusion. The fusion appears to break up the more resistant impurities contained and in some cases these come to the surface and may be readily removed by washing the surface of the fused cake as suggested by Mr. F. E. Smith. The fusion also furnishes a ready means of controlling the amount of acid in the final product, but especial precautions must be taken. Whether the silver nitrate is decomposed by heat when fused seems to depend less on the temperature than upon the amount of acid retained by the melted salt. As soon as the last trace of acid is expelled the salt begins to decompose into silver oxide and colloidal metallic silver as shown by the tests with iod-eosine and potassium permanganate respectively. By removing the salt from the furnace as soon as the last trace of solid material has melted it is found that a small amount of acid (1 or 2 parts in 100,000 of the solid salt) is retained and that this is sufficient to prevent decomposition, and in a 10 per cent solution is negligible in the voltameter.

Salt prepared in this way which is *satisfactory* for the voltameter is invariably a beautiful pearl white and never darkened as

noted by some earlier observers. The reasons why the salt recrystallized and fused according to the well known researches of Richards and Forbes (although well suited for their purposes of atomic weight determinations) is not suitable for use in the voltameter can only be given adequately in the complete paper to be published in Bulletin of the Bureau of Standards. It must suffice here to say that the authors have carefully followed their procedure and found the product unsuited for the voltameter, first because of the slight decomposition resulting from the prolonged fusion, and second because of the basicity formed from the repeated recrystallizations from neutral solutions.

In the fourth and last paper of this series the results subsequent to the work of the International Technical Committee will be given. These include experiments to determine the value of the Weston Normal Cell made with the highest precision and a discussion of the action of acid and base in the voltameter.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 712th meeting was held on October 12, 1912. In opening the meeting President Rosa remarked upon the present limitations of the field of the Society's activities, but stated that it had had a long and honorable career.

Mr. L. A. Fischer of the Bureau of Standards addressed the Society on *Some types of false weights and measures found in the United States*, in which it was pointed out that Congress has never adopted any of the standards now in customary use, altho it is the common impression that the yard, pound, gallon, and bushel are fixed by legislation instead of being fixed by custom, which is true. Due to the fact that we have no national legislation, the states have been compelled to enact legislation entirely independent of one another, and often laws of neighboring states have conflicted. As little or no attempt, however, was made to enforce them until recently, their diversity was of no importance.

A few years after the establishment of the Bureau of Standards or in 1904, invitations were sent to the governors of the states to send delegates to a conference to be held in Washington the following year for the purpose of securing uniform laws and regulations for weights and measures. Only eight states and the District of Columbia sent delegates, but so much interest was manifested by the delegates who attended, as well as by the authorities in those states which, for one reason or another, were unable to send representatives, that it was decided to hold subsequent conferences each year. Altogether seven conferences have been held, and much work of a constructive nature has been accomplished. A model law was drafted, and this law has been adopted with modifications to suit particular states, by thirteen states. In order to bring home to the authorities in the states that failed to become interested in the movement for better conditions, and also for the purpose of assisting the weights and measures officials in the states that were active, the Bureau made an investigation of the conditions of the weights and measures in general use thruout the country, as well as to investigate the manner of their use. Every state in the Union was visited, and inspections were made in 184 cities or towns ranging in size from New York City, with a population of 4,500,000, to Carson City, Nevada, with a population of 2200. A number of stores using weights and measures were visited in each town or city and the condition of the scales, weights and measures was noted.

Something over 30,000 scales, weights and measures were tested, and about 45 per cent of the scales were found to be 3 per cent or more in error, mostly favoring the dealer.

A little less than 4000 prints of butter were also weighed, and an average shortage of 0.05 ounce per pound or 3.25 per cent was found, taking the estimates of the Bureau of Standards as to the consumption of butter per capita, and assuming that 30 per cent of the butter is sold in the form of prints, and is retailed at 33 cents per pound, it is found that there is a loss to the consumers of the country of $8,228,000 from this one item, and that this shortage is not accidental is shown by the fact that prints of the same brand of butter sold in two cities, one of which had an ordinance requiring the net weight to be marked on the outside of the print, while the other had no such requirement, were full one-pound in the first case while consistently short in the second.

The results of the investigations were communicated to the state officials and to individuals interested in weights and measures reform in the states, and contributed very largely to the passage of the excellent laws recently adopted by the states.

The activity of the states has brought out the fact that some national legislation is necessary, in order to unify the standards and methods, and bills to effect this are now before Congress.

The 713th meeting of the Society was held on October 26, 1912, Vice-President Fischer presiding. Two papers were read.

*The 1912 excursion of the American Geographical Society:* Mr. W. J. Humphreys, of the U. S. Weather Bureau.

This excursion, trans-continental in scope, was eminently successful, and was in celebration of the sixtieth anniversary of the founding of the American Geographical Society and of the completion of its new home. Prof. W. M. Davis had charge of the arrangements of the trip, and of the personnel which consisted principally of distinguished persons from thirteen different European countries, more than half of whom were men the most eminent in their branches of work.

The special train on which the party traveled and its equipment were mentioned, and the route of travel and points of interest visited were briefly outlined and illustrated by a number of interesting lantern slides. The results of the trip were briefly summarized, among which may be mentioned the very favorable impression that the visitors received of America.

At the conclusion of Dr. Humphrey's paper the Secretary was formally directed to communicate to the American Geographical Society this Society's deep appreciation and thanks for the inception and successful execution of this memorable excursion, which must be productive of great and lasting good, not only thru its benefit to geography but also and especially by reason of the kindly personal relations thus established between learned and influential Europeans and Americans.

*Some results of the new method of gravity reduction:* William Bowie, of the Coast and Geodetic Survey. This Journal **2**: 499. 1912.

The 714th meeting was held on November 9, 1912. The following papers were read:

*Media of high refraction for use with the microscope:* H. E. Merwin, of the Geophysical Laboratory. The chief purpose of the results described was to make possible the identification of minerals. The microscope can be used for determination of refractive index of all solutions that are not opaque. A refractive index chart was exhibited covering a range of 1.5 to 3.0, and the physical properties of the mixture used to get this range were described. This range of media can be made standard by weighing out the materials. The absorption and heat effects were spoken of, and the variations of some of the media were described.

*The last meeting of the International Geodetic Conference at Hamburg:* O. H. Tittmann, of the Coast and Geodetic Survey. A brief account was given of the origin and growth of what is now the International Geodetic Association, and of its present organization and its work, this being followed by a brief outline of what the Hamburg meeting dealt with. The mode of government of the State of Hamburg was mentioned. About 50 delegates attended the conference from the 20 different countries represented. Much interest was taken in the reports on the variation of latitude work, and the next most important question was triangulation, of which the United States has generally reported the most work done. Isostasy was not much discussed. The social functions and points of interest visited were spoken of.

Under *Informal communications* Mr. Tittmann spoke of an automobile without springs, invented by Josef Hofmann, the pianist, and Mr. Bowie called attention to the completion of the marking of the boundary between Alaska and Canada north of the Yukon River, under the direction of Mr. Tittmann as commissioner on the part of the United States.

Before closing the meeting the chair announced the death of Dr. Robert Fletcher a past president of the Society.

The 715th meeting, held on November 23, 1912, was devoted to a general discussion of *The application of the microscope to physical problems*, the opening paper being given by Mr. F. E. Wright.

In introducing the subject the speaker grouped the uses of the microscope under three principal heads, (1) Qualitative, as a magnifying glass, a seeing instrument; (2) as a measuring device, and (3) as an optical instrument, such as for measuring the optical properties of minerals. Types of microscopes were exhibited and their construction and manipulation described, illustrating the above mentioned uses of microscopes. A number of accessories were also spoken of which are designed to facilitate and extend the use of the microscope, especially as a measuring and optical instrument. In the discussion which followed:

Mr. Briggs spoke of his experience with the ultra-violet microscope, pointing out its advantages and disadvantages, and the methods employed to overcome the disadvantages, such as finding the object to be seen after it is on the stage, in which resort was had to the use of a

fluorescent screen, against which it was difficult to focus the microscope. The focusing is assisted by the use of monochromatic blue light.

Messrs. ROSA and VINAL mentioned the use of the microscope in connection with the determination of the ampere with the silver voltameter, particularly with reference to the method of growth of silver crystals and the effect on their appearance when impurities are present.

Mr. BURGESS described a micropyrometer which is convenient for measuring melting points of microscopic samples.

Historical aspects and the present status of the microscope were discussed by Messrs. WEAD, FENNER, MERWIN, NUTTING, HUMPHREYS and TILLYER. The last emphasizing the use of the blue line of the mercury lamp as illuminator and suggesting an improved form of projection eye-piece.

The 716th meeting was held on December 7, 1912. Two papers were read.

*A consistent theory of the origin of the earth's magnetic field:* L. A. BAUER, of the Carnegie Institution of Washington. See this Journal **3**: 1. 1913.

*The earth inductor as an inclinometer:* N. E. DORSEY, of the Carnegie Institution of Washington: The speaker gave an outline of the theory of the earth inductor with a continuously rotating coil and commutator. When thermal electromotive forces exist in the circuit the setting of the coil for a zero glavanometer deflection depends upon the speed; if however, the axis of rotation lies in the magnetic meridian this effect of variations in the speed is usually very small. A method for adjusting the brushes so that commutation shall take place when the plane of the coil is parallel to the inclination axis was described. When the brushes are thus set, and the inclination of the coil is so adjusted that the deflection of the galvanometer is independent, in both magnitude and direction, of the direction of rotation of the coil, provided the speed is the same in both cases, then the direction of the axis of the coil is exactly the direction that would be taken by a perfect dip needle placed with its pivots parallel to the inclination axis of the inductor. This is true for all azimuths, and is independent of the presence of thermal electromotive forces, provided that they are independent of the direction of rotation of the coil. For use at sea it is the mean value of the galvanometer deflection that must be independent of the direction of rotation.

The 42d annual (717 regular) meeting was held on December 21, 1912, Vice-President Burgess in the chair. The meeting was devoted to hearing the annual reports of the officers and to the election of officers for 1913, the following being chosen: President, C. G. ABBOT; Vice-presidents, L. A. FISCHER, W. S. EICHELBERGER, G. K. BURGESS, WILLIAM BOWIE; Treasurer, R. B. SOSMAN; Secretaries, W. J. HUMPHREYS and J. A. FLEMING. General Committee: N. E. DORSEY, L. J. BRIGGS, E. BUCKINGHAM, B. R. GREEN, E. G. FISCHER, R. A. HARRIS, F. A. WOLFF, D. L. HAZARD, R. L. FARIS.

R. L. FARIS, *Secretary.*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 260th meeting, the first meeting for the fall, was held in the Cosmos Club, November 13, President Stanton in the chair. As an informal communication F. C. Schrader gave a brief account of an occurrence of bauxite in vertical fissure vein deposits thru limestone in the Bovard district of southern Nevada.

### REGULAR PROGRAM

*The work of the Conservation Congress:* David White. Mr. White. was introduced as the new Chief Geologist of the Geological Survey, this being the first public announcement of his appointment to succeed Mr. Lindgren. He was received with hearty applause.

*Reconnaissance in the Southern Wasatch Mountains:* G. F. Loughlin. The speaker presented certain structural and stratigraphic data collected during a reconnaissance survey of the ore deposits in the Wasatch Mountains from the Cottonwood district southward to the northern part of the Mt. Nebo ridge. The only Pre-Cambrian exposure south of the Cottonwood canyons is a band of Pre-Cambrian granite and schists extending for a mile along the base of the Santaquin ridge. This band is overlain unconformably by Cambrian quartzite about 800 feet thick. The Cambrian quartzite was found to include the occurrences mapped by the Fortieth Parallel Survey as the Ogden (Devonian) quartzite. The "Ogden" quartzite in the Cottonwood district proved to be a portion of the Cambrian, overthrust upon Madison (lower Mississippian) and older limestone, shale members in the overthrust quartzite carrying Cambrian fossils. Blackwelder's elimination of the Ogden quartzite in the northern Wasatch country is thus confirmed. The "Ogden" quartzite in the Cottonwood, as well as in the American Fork and Provo districts is overlain by the regular succession of Cambrian to Mississippian limestones—the same succession as is found above the Cambrian quartzite on the Santaquin ridge; but the thickness of the pre-Mississippian limestones is much less than in the Bear River ridge to the north or in the Tintic range to the southwest.

The stratigraphic section in the Cottonwood district is continuous from the Pre-Cambrian thru the Triassic; but southward the Weber (Pennsylvanian) have been bevelled off by an unconformity, since Eocene (Wasatch?) conglomerate, east of the Santaquin ridge, rests unconformably upon the upper Mississippian. West of Santaquin a veneer of the Eocene conglomerate rests upon pre-Mississippian limestone, and in the Sevier River Canyon, the same conglomerate rests upon Cambrian quartzite, thus showing that the whole Paleozoic section was bevelled by the unconformity. At all these localities the Eocene conglomerate is covered by patches of volcanic rocks, chiefly by a coarse andesitic breccia.

The principal structures noted are (1) westward overthrusts, including that already mentioned in the Cottonwood district and others at Santa-

quin and 7 miles still further south, Cambrian quartzite in every case overriding Mississippian limestone; (3) local doming and eastward reverse faulting around the intrusive Cottonwood granite stock; (3) fissuring and mineralization following the Cottonwood intrusion; (4) late normal (block) faulting which developed the Basin range. The latter is especially well exposed in the low western flanking ridges between Mt. Nebo and Santaquin, where the faults which lie along depressions can be proved by the discordant relations of the bed rock. The block faulting took place after the post-Eocene volcanic eruptions.

*New data on the "Knox dolomite" in Tennessee and the "Ozarkian" in Missouri:* E. O. ULRICH.

ROBERT ANDERSON, *Secretary.*

At the 261st meeting, held at the Cosmos Club on November 27, 1912, under informal communications, the following paper was presented:

*An occurrence of petroleum near Cody, Wyoming:* D. F. HEWETT. A petroleum spring was observed under unique conditions in the Akaroka Mountains, in northwestern Wyoming, during the summer of 1912. It is located on the west bank of Sweetwater Creek, 2½ miles north of its junction with the North Fork of Shoshone River, and is therefore about 26 miles due west of the town of Cody. The geology of the region is described by Hague in Folio No. 52, and the spring is situated in the basic andesite flows of Miocene age on the line (Lat. 40° 30′) between the Ishawooa and Crandall sheets.

The spring is unique in that it lies within 100 yards of several small sulfur deposits, situated on the east side of Sweetwater Creek. The sulfur deposits are identical in nature to those 12 miles north on Sunlight Creek, which were examined in 1911, and a report upon which appears in U. S. Geological Survey Bulletin No. 530, part O, 1911. The deposits embrace two classes of material: (1) sulfur which lies along the walls of open fractures in the lavas, and from which gases containing $CO_2$, $CH_4$ and $H_2S$ are issuing, and (2) sulfur filling the interstices of gravels and surface débris along stream channels. The second class of material probably covers fracture zones. The oil spring is opposite an area 100 feet square into which prospect pits have been sunk showing sulfur cementing angular rock débris to a depth of 9 feet. Other smaller deposits of sulfur lie 700 feet farther up the creek.

Oil was first recognized issuing from the sands adjoining the creek. In the hole which was dug along the bank, water and oil slowly accumulated and several quarts of clear light oil were thus collected during the summer of 1911. During the writer's visit a pit was dug near the location of the old one which had been destroyed by freshets. The sand at this point is dark brown and has an asphaltic odor, but otherwise is such as would form bars along rapid mountain streams. In the short time at the writer's disposal only enough oil was collected to give assurance of its identification, but not enough for analysis.

Tho the superficial rocks of this region are igneous flows and breccias, these rocks overlie a great thickness of sedimentary rocks ranging in

age from Cambrian to Eocene, the Mesozoic section alone being approximately 14,000 feet thick 25 miles east. The sandstones of the Lower Cretaceous are oil-bearing near Cody, and the oils are light, relatively clear, and have a paraffin base. Evidence in nearby regions shows that the sedimentary rocks are much folded and that the lavas are cut by many intricate fractures, some of which, at least, are of recent origin. Sandstones outcrop on Shoshone River, 2½ miles south of the oil spring and about 400 feet lower, so that the lavas at the sulphur deposit are probably not over 500 feet thick.

The oil is probably to be traced to the sedimentary rocks, but its close relation to the sulfur deposits is unusual.

#### REGULAR PROGRAM

*The Joplin lead and zinc deposits:* C. E. Siebenthal.

*Secondary enrichment in silver:* E. S. Bastin. Microscopic studies of specimens of silver ore collected by E. S. Bastin and J. M. Hill from the mines near Lawson, Clear Creek County, Colorado, and near Caribou, in Boulder County, show that the ores owe their value largely to downward sulfide enrichment. The rich secondary sulfides are developed not only in cracks in the original ore, but as metasomatic replacements of galena and quartz. Sketches were exhibited illustrating such replacement. In the belief that such phenomena were of rather widespread occurrence, a specimen collected by W. H. Weed from the Big Seven mine, Neihart district, Montana, was polished and examined under the microscope. Replacements similar to those in the Colorado ores were well shown by the Montana specimen.

Certain mineralogical differences between the ores which exhibited enrichment in silver and other ores in the district which did not exhibit such replacement were pointed out. R. W. Richards, *Secretary.*

## PROGRAMS AND ANNOUNCEMENTS

### THE WASHINGTON ACADEMY OF SCIENCES

January 30 at 8.15 p.m., Cosmos Club Assembly Hall. Illustrated lecture by Dr. Arthur L. Day, *Some observations on the volcano Kilauea in action.*

### THE BOTANICAL SOCIETY OF WASHINGTON

The 86th regular meeting of the Botanical Society of Washington will be held in the Assembly Hall of the Cosmos Club at 8 p.m., Tuesday, February 4, 1913.

#### SCIENTIFIC PROGRAM

Brief Notes and Reviews of Literature.

T. H. Kearney, *Indicator value of natural vegetation in the Tooele Valley.*

H. B. Shaw, *The control of seed production in beets.*

The program will be followed by a social hour, with refreshments.

THE PROCEEDINGS

OF THE

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VOL. III. No. 3.

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# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES



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JOURNAL

OF THE

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Vol. III, FEBRUARY 4, 1913 No. 3

PHYSICS.—*Suggestions for frost protection.* Karl F. Kellerman, Bureau of Plant Industry.

The high thermal capacity of water has made possible the development of more or less elaborate enclosed systems for warming air spaces, such as living rooms, but very little attention has been paid to the utilization of water in efforts to protect orchards from frost. It would seem, however, that the rapid and efficient distribution of heat occasionally necessary in orchards, where modern systems of frost prevention are employed, could be controlled more satisfactorily and with less expense thru a development of water-heating systems.

The rapid evaporation when fine sprays of water are driven into the open air in summer weather has a cooling effect, due to the absorption from the air of a quantity of heat equal to the latent heat of vaporization of the water evaporated, which is so far in excess of the quantity of heat delivered to the system by the water introduced, that a short experiment under these conditions is misleading. The rapid decrease, with decreasing temperature, of the tension of aqueous vapor would make easily possible the artificial saturation of air at or below 0°. As soon as this artificial dew-point has been established the high calorific value of water vapor, or finely divided particles of water, would become operative.

Three methods of thus utilizing water appear possible: (1) the atomizing, or spraying by the use of power sprays, of fine mists

of water which might be warmed at a central station; (2) the suspension of pans holding small quantities of water above each of the fire pots now in use; and (3) the pumping, thru a permanent system of pipes, of steam generated at a central station and mixed with large quantities of air to prevent condensation in the pipes.

While there would be a considerable water economy in the use of steam by either the second or third methods, the feasibility of water heating will be sufficiently well illustrated by describing with approximate figures the theoretical possibilities of only the first method.

If we neglect for the moment the effect of evaporation and the presence of water vapor in the air, the heat liberated by 1 liter of water in cooling from 90° to 0° C. is, in round numbers, capable of raising the temperature of 296,100 liters of air from −1° to 0°C. To raise the temperature of a column of air 3.29 meters high and covering 1 hectare from −1° to 0° should therefore take approximately 111 liters of water at 90°. Assuming that the humidity of such a column of air was 80 per cent, and that at a temperature of −1° it would be saturated by 155 liters of water, the evaporation of the 31 liters of water required for saturation would absorb heat equivalent to that given off in cooling 184 liters from 90° to 0. The very small quantity of hot water, about 1 liter, required to raise the temperature of this aqueous vapor from −1° to 0° is almost negligible. For the rise of each degree, however, approximately 1.1 liters must go to saturate the column of air under discussion, and in evaporating this quantity of water heat is absorbed equivalent to that given off in lowering 7.4 liters of water from 90° to 0°. The total quantity of water at 90° which must be thoroly distributed to cause the initial rise from −1° to 0° of the air column 3.29 meters high, covering 1 hectare, is therefore 111 + 1 + 208.9 + 7.4 = 328.3 liters; the subsequent rise from 0° to 1° would require 111 + 1 + 1.1 + 7.4 = 120.5 liters of water at 90°; the increase from 1° to 2° would require 111 + 1 + 2.5 + 7.4 = 121.9 liters of water at 90°; and the increase from 2° to 3° would require 111 + 1 + 3.9 + 7.4 = 123.3 liters at 90°.

For a body of air 26 feet deep, covering 1 acre, 86.7 gallons of

water at 194°F. would be necessary to raise the temperature from 30.2°F. to 32°F., if the humidity was 80 per cent; 31.8 gallons more would be required to raise the temperature to 33.8°F.; 32.2 gallons additional for 35.6°F.; and 32.6 gallons additional for 37.4°F. Probably much larger quantities would be necessary in actual practice, due to loss of heat by convection currents, by imperfect distribution of the water and by the radiation continually taking place into the air outside of the heated zone.

In still air this proposed vapor system has the advantage of the protective quality of the fog thus artificially produced, due both to lessening the radiation from the earth and to the heat given off if the water particles actually began to freeze.

GEOLOGY.—*Some variations in Upper Cretaceous stratigraphy.*[1] TIMOTHY W. STANTON.

That the stratigraphic development of the Cretaceous has been different in distinct basins of sedimentation is well understood. No one would think of applying the same set of formation names to the Upper Cretaceous rocks of the Rocky Mountain region and to those of the Atlantic coastal plain or to those of the Pacific border. The physical conditions of sedimentation were very different and they have resulted in different lithologic successions and in more or less distinct faunal facies. The fact that there is great local variation, often within short distances, in a single area like that of the Rocky Mountains and adjoining Great Plains has been slower of recognition. It is true that the extension of more detailed work, especially when accompanied by areal mapping, has brought such local variations into prominence in many places but their importance has apparently often been overlooked by geologists, whose natural tendency is to apply the old established stratigraphic standards when they enter neighboring new fields, even when they realize that the standards must be warped and the new facts distorted in order to make the adjustment.

It may be of interest to cite a few cases of local variation, taking

[1] Published by permission of the Director of the United States Geological Survey. Presidential address delivered before the Geological Society of Washington, December 11, 1912.

the examples entirely from the region of the Rocky Mountains and adjacent plains, from central New Mexico northward to the Canadian boundary and confining them to that part of the Upper Cretaceous column which is within the limits of marine sedimentation for the region and does not involve any possible unconformities.

The classic upper Missouri section of Meek and Hayden[2] recognized only five formations, viz.:

| | feet |
|---|---|
| Fox Hills sandstone | 500 |
| Fort Pierre shale | 700 |
| Niobrara limestone | 200 |
| Fort Benton shale | 800 |
| Dakota sandstone | 400 |

(See Section No. 1, p. 58)

The thicknesses given were of course mere estimates based on rapid reconnaissance over great distances, the type localities being scattered from eastern Nebraska to central Montana. The section actually passed far to the west of the area in which the Niobrara limestone is developed and crossed a region where a large part of the Pierre shale is represented by littoral, estuarine, and terrestrial deposits. With his standard Cretaceous section recognizing only two sandstones, one at the top and the other at the bottom, it is no wonder that Hayden wavered in his assignment of the sandstones beneath the Judith River formation, sometimes referring them doubtfully to the Dakota and later correlating them with the Fox Hills.

The geologists of the Fortieth Parallel Survey found that the Niobrara did not retain its lithologic character so as to be recognizable over a large part of the area surveyed by them and they therefore attempted to map as one great shale group all the rocks lying between the Dakota and the Fox Hills. They also appreciated the fact that the Cretaceous sediments in the neighborhood of the Wasatch Mountains, at Coalville, Utah, for example, include an unusual development of sandstones thruout the section, which they attributed to near shore conditions, but if they did not succeed in making a consistent map and section of the Upper Cretaceous it was largely because they adopted the

[2] Proc. Acad. Nat. Sci., Philadelphia, 1861, p. 419.

idea that there are no important or persistent sandstones between the Dakota and the Fox Hills, while the fact is that in the area of their map this interval includes two thick coal-bearing formations in which sandstones are the dominant feature.

Evidently at least one new standard section, with modified nomenclature, was needed and this was furnished in southwestern Colorado. Holmes and others on the Hayden Survey nearly forty years ago had shown that the stratigraphic development differed considerably from that of the sections in the upper Missouri region and in Colorado east of the mountains. In the course of the areal work under the direction of Cross, the grouping and nomenclature of Holmes' section were modified and published in the La Plata and Telluride folios[3] from which the following descriptions are condensed (Section No. 2, p. 58):

*Lewis shale.* More or less sandy gray or drab shale with thin lenses or concretions of impure limestone. Thickness in Durango quadrangle, 2000 feet.

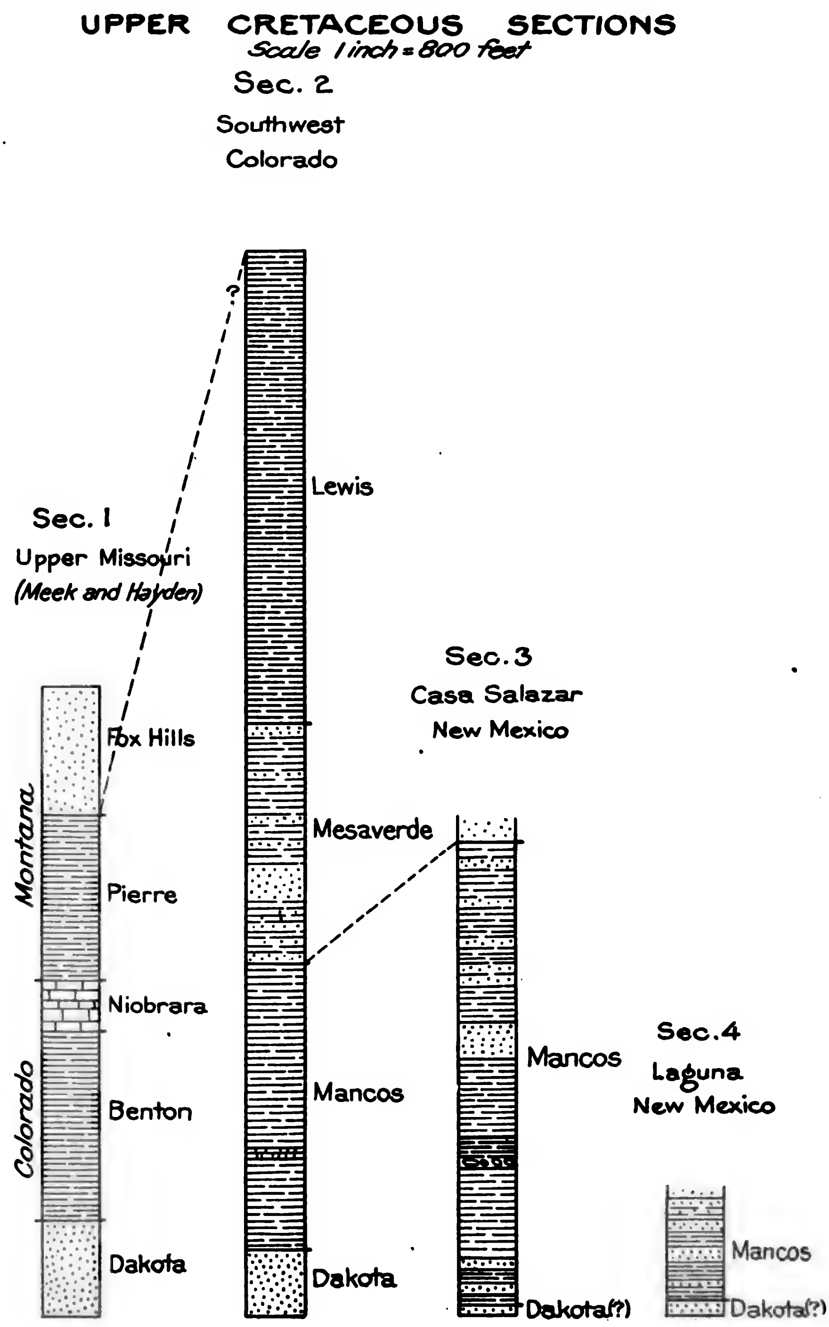
*Mesaverde formation.* Alternating sandstones and shales with occasional marls or thin limestones and a number of coal beds. Lower 250 feet form a transition from Mancos shale followed by heavy sandstone 125 feet thick. At top a massive sandstone 25 feet thick. Total thickness, 1000 feet.

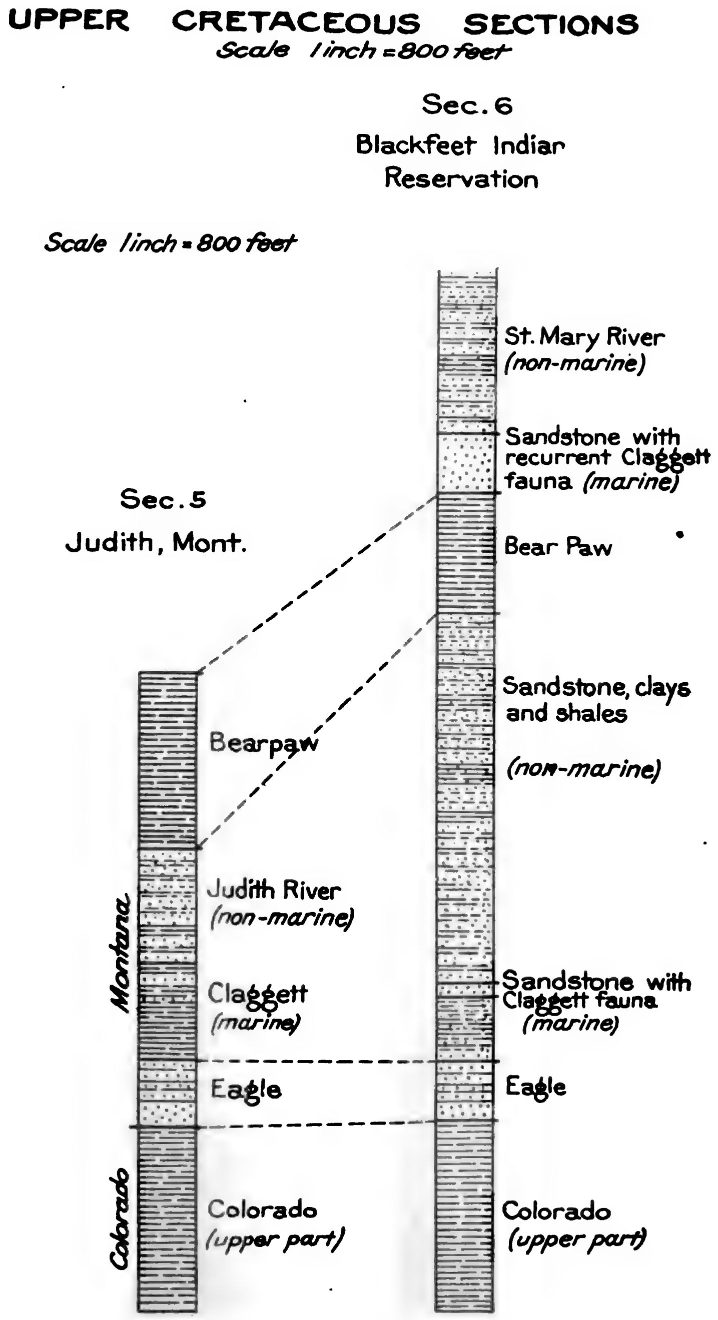
*Mancos shale.* Soft, dark-gray or almost black carbonaceous clay shale containing thin lenses or concretions of impure limestone. Thickness, 1200 feet.

*Dakota sandstone.* Gray or rusty brown quartzose sandstone with variable conglomerate. 100 to 300 feet.

The names Lewis, Mesaverde and Mancos have since been applied with varying success and acceptability thruout western Colorado, northwestern New Mexico, eastern Utah, and southern Wyoming. As described in the different areas each of these formations varies greatly in thickness and considerably in lithologic character. For the purpose of showing the nature of this variation let us take the Mancos shale which over a large area is limited above and below by the easily recognized Mesaverde formation and the Dakota sandstone, respectively. In the type section just west of the La Plata quadrangle the Mancos consists of 1200 feet of dark gray shale containing some lenses or concretions of impure limestone, but in the Telluride quadrangle

[3] Geologic atlas of the United States, Folio 60 and 57.


UPPER CRETACEOUS SECTIONS
Scale 1 inch = 800 feet
Sec. 2
Southwest
Colorado
Lewis
Mesaverde
Mancos
Dakota
Sec. 1
Upper Missouri
(Meek and Hayden)
Fox Hills
Pierre
Niobrara
Benton
Dakota
Montana
Colorado
Sec. 3
Casa Salazar
New Mexico
Mancos
Dakota(?)
Sec. 4
Laguna
New Mexico
Mancos
Dakota(?)


UPPER CRETACEOUS SECTIONS
Scale 1 inch = 800 feet
Sec. 6
Blackfeet Indian Reservation
Scale 1 inch = 800 feet
St. Mary River (non-marine)
Sandstone with recurrent Claggett fauna (marine)
Sec. 5
Judith, Mont.
Bear Paw
Sandstone, clays and shales
(non-marine)
Bearpaw
Judith River (non-marine)
Montana
Claggett (marine)
Sandstone with Claggett fauna (marine)
Eagle
Eagle
Colorado
Colorado (upper part)
Colorado (upper part)

a short distance to the north it is said to be 2000 feet thick and is described as "gray sandy shale with calcareous bands and sandstones." Eastward, however, for nearly 100 miles thru the La Plata and Durango quadrangles and on to Monero, New Mexico, the work of Schrader[4] and Gardner[5] has shown that the Mancos shale maintains about the same thickness and character as at the type locality. From Monero southward along the eastern border of the great San Juan area, past El Vado to Gallina and beyond, a distance of about 50 miles, it continues to be essentially a shale with no conspicuous sandstone intercalations. On this point the observations of Lee and Stanton on a recent reconnaissance from Albuquerque to Monero confirm the descriptions of Gardner who mentions a sandstone 30 feet thick, 275 feet below the top of the Mancos, 10 miles north of Gallina and states that farther south the upper part of the formation consists of 300 feet of argillaceous sandstone and sandy shale grading up into the Mesaverde formation. The important point to be remembered is that so far the lower three-fourths of the Mancos contains no sandstones except a band usually about 50 feet thick, of yellowish thin-bedded, shaly, somewhat calcareous sandstone and sandy shale, characterized by *Ostrea lugubris*, *Scaphites warreni*, and *Prionocyclus wyomingensis*, representing one of the most useful, widespread and persistent faunal zones in the Upper Cretaceous of the Rocky Mountain region. At Mancos this horizon is about 400 feet above the Dakota but the distance from the Dakota varies considerably, doubtless on account of variation in the rate of sedimentation.

South of Gallina along the west base of Naciemento Mountains structural complications and an overlap of the Tertiary prevent continuous observation of the Mancos for about 20 miles but the overlying Mesaverde is readily recognized when it reappears and is continuously exposed to the neighborhood of Cabezon where it swings west with a low northerly dip. From that point southward the underlying rocks, including the Mancos, are splendidly exposed along the Rio Puerco for 35 miles to

[4] U. S. Geol. Survey, Bull. 285, pp. 241–258.
[5] U. S. Geol. Survey, Bull. 341, pp. 335–351. Jour. of Geology, **18**: 702–741.

San Ygnacio where they have been described in general terms by Herrick[6] and Johnson and in greater detail by W. T. Lee.[7] The Mancos is here expanded to a thickness of fully 2000 feet and it includes several cliff-making sandstones so that its general aspect is greatly altered (Section No. 3, p. 58.)

The upper 800 feet or more consist of more or less sandy shale, generally weathering yellowish, with many bands and lenses of soft sandstone. Beneath this is a massive, yellowish, cliff-making sandstone approximately 100 feet thick separated by 350 feet of dark shale from the brownish, shaly, calcareous sandstone which forms the zone of *Ostrea lugubris* and *Scaphites warreni* already mentioned. Beneath this zone is another dark shale, about 500 feet thick, followed by Herrick and Johnson's "Tres Hermanos" sandstone which consists of two distinct massive beds 66 feet and 37 feet thick, respectively, separated by about 50 feet of dark shale. Another dark shale, 55 to 60 feet thick, intervenes between the basal bed of the "Tres Hermanos" sandstone and another somewhat variable sandstone which seems to represent the Dakota, although it is here only from 25 to 40 feet thick.

The section of the Mancos just described is all well exposed in the west side of Prieta Mesa on the Rio Puerco near the village of Casa Salazar and the sandstones, especially the "Tres Hermanos," make conspicuous cliffs on frequent exposures for 25 miles along the Rio Puerco. There are minor variations in the thickness of individual members but the general character is consistent thruout this distance. According to the faunal evidence the 1200 feet of rocks immediately above the Dakota (?) should all be correlated with the Colorado group, and this part of the section instead of being all shale, as in the typical Mancos, includes at least 200 feet of sandstone in three massive beds. A still further increase in the sandstones of the part of the section corresponding to the "Tres Hermanos" sandstone and associated

[6] Geology of the Albuquerque sheet (New Mexico). Denison Univ. Sci. Lab. Bull. vol. xi, art. ix, pp. 175–239.

[7] Stratigraphy of the coal fields of northern central New Mexico. Bull. Geol. Soc. Am. **23**: 571–685.

shales may be seen at Laguna, New Mexico, about 30 miles southwest of the exposures just described. Here within the 350 feet immediately above the Dakota (?),[8] which is 85 feet thick, there are three massive cliff-making sandstones instead of two, and the overlying 75 feet beneath the lava cap is a sandy shale with soft sandstone bands. Marine fossils are abundant and characteristic so that there is ample evidence for detailed correlation. (Section No. 4, p. 58.)

These New Mexican exposures may perhaps all be legitimately called Mancos though it may be questionable practice in the localities most remote from well recognized Mesaverde. In southern Utah where the name is not appropriate the equivalent of the lower, or Colorado portion of the Mancos may still be very definitely determined by means of two or more paleontologic zones which are common to southern Utah and the part of New Mexico which has just been discussed. Sections recently studied by Richardson[9] in Kanab Valley and further west in the Colob plateau show a thickening of this part of the section and a greater development of sand stone as compared with the New Mexican section, together with the intercalation of coal beds and brackish and fresh-water sediments in the basal portion. They also show according to unpublished data great local increase in the relative proportion of sandstone and in the total thickness of the sediments in passing a short distance west from Kanab Valley.

Some of these southern Utah sections show close resemblance to the Coalville section in northern Utah and it in turn has many points in common with the immensely thick section described by Veatch[10] and Schultz[11] in Uinta County, Wyoming, the southwest corner of the state. In the Uinta county section beneath the "Laramie" formation in descending order come the Hilliard shale, consisting of gray to black sandy shale and shaly sandstones

[8] Darton has published a section of the Cretaceous rocks exposed 2 miles northeast of Laguna (U. S. Geol. Survey Bull 485, p. 60) in which numbers 8 and 9 correspond to the Dakota(?) of my section. The underlying rocks, over 300 feet in thickness are suggestive of Morrison.

[9] U. S. Geol. Survey, Bull, 341, pp. 379–400.

[10] U. S. Geol. Survey, Prof. Paper No. 56.

[11] Ibid., Bull 316, pp. 212–241.

5300 to 6800 feet thick; the coal-bearing Frontier formation with yellow and gray sandstone, yellow, gray and black carbonaceous shales and numerous coal beds, 2200 to 2600 feet thick; the Aspen shale, 1500 to 2000 feet thick; and the fresh- and brackish-water Bear River formation which attains a thickness of 5000 feet.

For the present purpose the chief interest in this great section lies in the fact that it is so unlike the sections in areas a short distance to the east, as at Rock Springs, 70 miles east, described by Schultz,[12] and in the Rawlins district, 80 miles farther east, described by Veatch,[13] Ball,[14] and E. E. Smith.[15] In these more eastern sections the Bear River is absent as might be expected. Its place in the section is occupied by a thin representative of the Dakota sandstone. The Frontier is faintly recognizable in a comparatively thin sandstone-bearing formation without coal. It is overlain by a great mass of dark clay shale, sandy shale and shaly sandstone 4000 to 5000 feet thick followed by a thick and very important coal-bearing formation and a marine shale for which the names Mesaverde and Lewis, respectively, have been brought in from Colorado. Assuming that Mesaverde is here correctly identified the logical treatment would be to apply the name Mancos to all the rocks between the Mesaverde and the Dakota but on account of the great thickness of those beds and their partial differentiation into members that have come in from other areas on the east and west this has not yet been done. The Mesaverde and Lewis together apparently represent, in part at least, the Hilliard shale of the Uinta County section. Both these sections show very great thickening so that the total sediments from the base of the Mancos or Colorado up, amount to more than 10,000 feet. The chief difference lies in the fact that the Uinta County section develops a great coal-bearing formation of sandstone and shale in the lower part within the equivalent of the Colorado group, while the Rock Springs and more eastern sections have no coal in that part of the column but

[12] U. S. Geol. Survey, Bull. 341, pp. 256–282.
[13] Ibid., Bull. 316, pp. 244–260.
[14] Ibid., Bull. 341, pp. 243–255.
[15] Ibid., Bull. 341, pp. 220–242.

develop a similar great coal-bearing formation in the upper or Montana portion. These widely different neighboring sections seem to me to represent the varied and shifting sediments laid down in and on the borders of a single body of water. Slight warping of the surface, or local changes in the rate of sedimentation from whatever cause, would serve to shift the area of sea and coastal swamp from time to time.

One more standard section, with the changes and variations in its formations as they are followed away from their typical area, remains to be examined. In connection with their stratigraphic study of the Judith River formation Stanton and Hatcher[16] established the following succession in northern central Montana:

*Bearpaw shale.* Dark clay shale with marine fauna, 750 feet?

*Judith River formation.* Variable shales and soft sandstones with dinosaurs and other reptiles and fresh- and brackish-water invertebrates, 500 feet.

*Claggett formation.* Dark clay shale with several beds of sandstone especially in the upper portion. Marine fossils throughout—those of the sandstones containing many Fox Hills species, ± 400 feet.

*Eagle sandstone.* White, gray and yellowish sandstone with shale and coal in upper part. Marine shells, land plants and dinosaurs, 200 to 300 feet.

*Colorado shale.* Dark marine shale, 800 feet or more.

(See Section No. 5, p. 59.)

Compared with the southwestern Colorado section the top of the Colorado shale in this section is believed to be somewhat lower in the general column than the top of the Mancos but with this exception the Eagle, Claggett, and Judith River, taken together, are comparable in a general way with the Mesaverde, and the Bearpaw is approximately in the position of the Lewis.

The formations above the Colorado shale described in the neighborhood of Judith, Montana, were found to be easily recognizable along the Missouri River in the type area above and below the mouth of Judith River; on Milk River from the neighborhood of Havre to the Canadian boundary and beyond; and southward in the valley of the Musselshell. These formations have since been mapped by the geologists of the Fuel Section

[16] U. S. Geol. Survey, Bull. 257, pp. 11–14.

of the Survey over large areas in Montana and the limits of their areal distribution are now fairly well known. The most persistent is the Eagle sandstone which has been recognized as far south as the Bighorn Basin and northwest to the western limit of the Great Plains in northern Montana. The overlying Claggett, Judith River and Bearpaw formations in many localities lose their distinguishing features within shorter distances. None of them has been recognized as such east of the typical area. In that direction the fresh- and brackish-water beds of the Judith River doubtless soon grade laterally into marine shale so that there is no basis for distinguishing Claggett and Bearpaw from Pierre. Toward the south and west, on the other hand, the marine sediments of the Claggett and Bearpaw tend to be replaced and represented by estuarine and continental deposits.

A striking example of rapid variation of this kind has been described by Stone and Calvert[17] in the area surrounding the Crazy Mountains where within a short distance the Claggett, Judith River and Bearpaw finger out, and at last completely lose their identity in andesitic tuffaceous deposits which have been included in the Livingston formation.

Conditions somewhat similar, except for the absence of volcanic material, are found in the Bighorn Basin where the Eagle sandstone is recognized but the attempts to apply Claggett, Judith River and Bearpaw to the overlying formations have not been much more successful than the earlier attempts to apply the Meek and Hayden nomenclature in the same area. The marine Bearpaw shale just enters the northern end of the basin as a thin bed which soon wedges out completely. The reports of Woodruff[18] and Washburne[19] and the unpublished, more detailed work of Hewett show that over a large part of the Bighorn Basin especially on the west side there are no marine sediments above the Eagle sandstone, which is itself there only in small part marine, and that the thick interval between the Eagle and the well-identified Fort Union is occupied by fresh-

[17] Economic Geology, **5**: 551–557, 652–669, 741–764, 1910.
[18] U. S. Geol. Survey, Bull. 341, pp. 200–219.
[19] Ibid., Bull. 341, 165–199.

water or continental deposits which, while very irregular and varied, are yet uniform throughout in the character of their variation. That the time equivalents of Claggett, Judith River and Bearpaw, as well as the overlying Lance, are all included in these non-marine deposits seems to me the most reasonable assumption, tho it is perhaps not yet capable of complete proof.

Another area in which there is a different development of the rocks between the Eagle sandstone and the Bearpaw shale is the Blackfeet Indian Reservation in Montana just south of the Canadian boundary and east of the Rocky Mountain front somewhat more than 100 miles northwest of Judith. (Section No. 6, p. 59.) During the past two seasons the areal mapping and detailed stratigraphy have been done by Mr. Eugene Stebinger thru whose courtesy I am permitted to make these general statements based on his detailed work and on data obtained during two visits which I have made to the field. The Eagle sandstone resting on Colorado shale with a low dip to the west is normally developed and forms a conspicuous escarpment extending from near Cutbank in a northerly or northeasterly direction to the Canadian line. The Bearpaw shale of typical character and with a marine fauna, here somewhat meagerly developed, is nearly 500 feet thick. Between these two formations there are almost 2000 feet of sediments in which no practicable formation boundaries can be drawn and which Stebinger has therefore mapped as a unit altho it must include the time equivalents of both Claggett and Judith River. Lithologically it has a closer resemblance to Judith River and like that formation it is essentially non-marine. It contains Unio, Viviparus, and other fresh-water shells at various horizons from the top to within 200 feet of the base. There are also dinosaurs and land plants, and locally thin brackish-water beds are found with Ostrea, Corbula and Corbicula, especially at the top and in the lower portions. No evidence of marine fossils or sediments had been found in the formation until September of this year when at the town of Cutbank I found marine fossils locally abundant in a sandstone 50 feet thick which forms the top of the east wall of the gorge of Cutbank Creek about half a mile south of the town. The horizon is not

more than 300 feet above the Eagle sandstone and hence should be in the equivalent of the Claggett formation. Or, to locate it more accurately, according to Mr. Stebinger it is immediately above the horizon of a thin coal which he has traced down the creek from the "Allison mine" a few miles northwest.

Now the marine fossils found at this place belong to the fauna which occurs in the sandstones of the Claggett formation at its type locality and include among the more abundant and conspicuous forms *Tancredia americana*, *Cardium speciosum*, *Mactra formosa*, etc. This is the fauna which in the past Meek, White, Stanton, and others have called a typical Fox Hills fauna because these conspicuous and abundant forms—the dominant species as Prof. H. S. Williams calls them—do recur in the Fox Hills sandstone at the top of the Cretaceous column.

This recurrent fauna when it reaches the Fox Hills is, of course, not absolutely identical with the sandstone fauna of the Claggett, but there are enough conspicuous, identical species to make identification of the horizon uncertain unless the collections are complete or the stratigraphic details fully known. Recurrent faunas are often troublesome and embarrassing to the stratigraphic paleontologist and still more so to the stratigrapher who is not a paleontologist. It is even difficult to prove that the fauna is recurrent at a higher horizon when the two localities are as far separated as central Montana and the middle of South Dakota, as they are in the case of the type localities of the Claggett and the Fox Hills, although the stratigraphic position of the Claggett was determined in 1903 independently of the evidence of that particular fauna and in contradiction of the interpretation that had been placed on it. There are also many localities now known where the stratigraphic position of the fauna in question, at one or the other of the two horizons, is well determined. For these reasons the argument set forth in a recent article by A. C. Peale[20] that the upper sandstones of the Claggett are identical with the Fox Hills is altogether fallacious in so far as it is based on lithologic and faunal resemblances. Nevertheless it was gratifying to find this Claggett-Fox Hills fauna in the normal position of

[20] Jour. of Geology, **20**: 530-549, 640-652, 738-757, 1912.

the Claggett formation and again recurring about 2000 feet higher in the same section where there is no reason to question the structure or stratigraphic position. At Cutbank the fossils are about 300 feet above the Eagle or more than 1500 feet below the Bearpaw. From this locality there are practically continuous exposures down Cutbank Creek to its mouth where the base of the Eagle is exposed. Thence westward up Two Medicine Creek there are continuous exposures and simple structure up to and thru the Bearpaw with its 500 feet of dark shale. Above the Bearpaw is a sandstone which makes conspicuous cliffs near the Holy Family Mission (Family P. O.) on Two Medicine Creek. Here and at other exposures farther west on the creek it yielded *Tancredia americana*, *Cardium speciosum*, Mactra, etc., identical with those found at the much lower horizon, together with a number of other forms not found there. This sandstone is approximately in the position of the Fox Hills and is doubtless the same sandstone which Dawson identified as Fox Hills in the adjacent area on the north, tho from the evidence at hand it would be rash to say that it is strictly identical with the Fox Hills of South Dakota. At most localities where it has been examined in the Blackfeet reservation it has proved unfossiliferous or yielded only *Ostrea subtrigonalis* and other brackish-water forms which are found both in Dawson's St. Mary River formation above it and in the beds beneath the Bearpaw, but here, on Two Medicine Creek, there was an incursion of strictly marine water with an abundant fauna of Fox Hills type.

After this brief digression in pursuit of a recurrent fauna let us return, for a few moments, to the main topic, which is contemporary variation in sedimentation and its bearing on stratigraphy and geological history. The sedimentary records of the Blackfeet country, aided by the paleontologic evidence, show that during the long quiet deposition of the Colorado shale and while the Eagle sandstone was being laid down by the stronger currents of the shallowing sea the physical conditions there were about the same as in a large area on the east and southeast. Later, during Claggett time, while purely marine conditions still prevailed a short distance to the east, near Judith, for example,

the Blackfeet country was slightly elevated so that it was occupied by coastal swamps and lagoons only a few feet above tide into which slight depressive movements occasionally brought local and temporary brackish waters and still more rarely a brief incursion of the sea, as is proved in one case by the fossils found at Cutbank. The Bearpaw shale marks a more important marine incursion which probably covered the whole area and continued for some time though it is questionable whether it lasted as long here as it did in central Montana. At the close of Bearpaw sedimentation there was clearly another considerable period of transition when the area wavered near tide level and received first marine and then brackish-water sediments before land conditions were at last permanently established.

We are now in position to understand the difficulties which Dawson[21] encountered in describing and interpreting his section of the "Belly River series" along Milk River north of the international boundary. It was another case of applying the terminology of a single section thru a long stretch of country in which the stratigraphic development varied. In the eastern portion where Dawson got the best evidence that the "Belly River" is intercalated between two marine formations the section is like that at the mouth of Judith River while in the western portion it is the same as in the Blackfeet Indian reservation. In 1903 Hatcher and Stanton visited the localities near Pakowki Lake and correctly identified as Claggett the "lower dark shale" there exposed beneath the "Belly River," thus establishing the identity of the "Belly River" of that section with the Judith River formation. The mapping of Stebinger has now shown that the "lower dark shale" on the escarpment of Rocky Spring Plateau about 40 miles west of Pakowki Lake is Colorado shale and Dawson's "Belly River" from that point west includes the Eagle sandstone and all the overlying rocks to the base of the Bearpaw. Between these two localities the marine Claggett shale has merged into non-marine sandstones and shales.

In conclusion the general statement is justified that the Upper Cretaceous sediments of the Rocky Mountain region show as

[21] Geol. Survey of Canada, Rept. for 1882–83–84, pp. 111 C–126 C.

great contemporary local variation in a single basin as may be found in the deposits now forming along any modern coast. The local character of many of the beds, the rapidity with which they merge laterally into others of unlike lithologic character make it necessary to use many local formation names. They should also make the geologist cautious in his interpretations of the absence of any particular bed or formation. When, for example, a sandstone which forms the top of the marine Cretaceous section in one area is absent in another area its absence may be due to erosion, but its apparent absence may also be due to the fact that the sandstone is there represented by a shale or by non-marine deposits of a totally different character.

GEOCHEMISTRY.—*Chalcocite deposition.* ARTHUR C. SPENCER, Geological Survey.[1]

The most common secondary sulfide in many copper mining districts is chalcocite, occurring under conditions which indicate that deposition has taken place from solutions containing copper sulfate. It is not difficult to show that the direct or indirect source of this dissolved copper compound is chalcopyrite which may be termed primary, and it is a matter of observation that the same double sulfide of iron and copper is a very effective precipitant or localizer of chalcocite. Pyrite has been usually regarded as the most common nucleus for secondary chalcocite, but in certain districts chalcopyrite must be recognized as occupying this rôle instead of pyrite. The presence and proportion of chalcocite in ores now being mined on a large scale in several districts determines their commercial value. This is notably true of the so-called porphyry ores in which the metallic sulfides are thoroly disseminated thru great masses of rock.

In 1903 H. V. Winchell[2] published the results of experiments devised to indicate the probable conditions under which chalcocite has been deposited in the veins of the Butte district from waters carrying cupric sulfate. The determining agent in the deposition was thought to be $SO_2$, and later[3] A. N. Winchell

[1] Published by permission of the Director.
[2] Bull. Geol. Soc. Am. **14**: 269–276. 1903.
[3] Economic Geology **2**: 290–294. 1907.

showed that $SO_2$ is actually one of the products when pyrite undergoes oxidation. In a recent discussion of this subject Tolman,[4] who was associated with H. V. Winchell, has used the results of these two investigations as the basis for an understanding of the chemistry of secondary chalcocite. Previously, however, it had been argued by Lindgren,[5] that the scheme suggested by Winchell is open to criticism because no indication is given as to how $SO_2$ generated in the upper oxidizing zone could reach the situs of chalcocite deposition, since it would be destroyed in transit by contact with products of pyrite decomposition.

On its face this reasoning against the Winchell hypothesis appears to be adequate, but the fuller analysis here presented tends to show that $SO_2$ may still be an actual factor in the reaction. Since the writer does not have that unwavering faith which would find in every balanced chemical equation a truth of fundamental value, it is recognized that the equations of the series here given afford no demonstration. They do however, furnish a convenient shorthand to assist in analytical discussion, and some of them are allowable expressions of known actions.

Chalcocite, deposited in molecular replacement of primary sulfides, is a side product of the culminating reaction in a series of oxidizing effects which occur in situations where water and air penetrate from the surface to cupriferous sulfide-bearing rock or vein stuff. The full series of reactions may be divided conveniently and logically into three groups, assignable to a higher, an intermediate, and a lower position in the body of sulfide-containing material. If considered with respect to the minerals which suffer decomposition these reactions present a succession of oxidations, while with respect to the active solution the changes are of course as consistently in the direction of reduction. Group I comprises the reactions of complete oxidation on the upper edge of an ore body where free oxygen is present. Group II comprises reactions ensuing at slightly greater depth and involving oxidation of sulfides (both primary and secondary) by contact with ferric sulfate. Group III, occurring at still greater

[4] Min. Sci. Press **106**: 42. 1913.

[5] Copper deposits of Clifton-Morenci. Prof. Paper U. S. Geol. Survey No. 43, p. 184. 1905.

depth, includes oxidation of sulfides (primary only) by contact with cupric sulfate. Or, if the solution is considered rather than the minerals with which it comes into contact, the three groups of reactions involve successively depletion of free oxygen; reduction of ferric to ferrous sulfate; and finally the decomposition of cupric sulfate derived from previous reactions. This last reaction is, as a whole, one of double decomposition in which soluble ferrous sulfate and insoluble cuprous sulfide are formed at the expense of cupric sulfate and pyrite or chalcopyrite.

Several of the equations which may be written to represent tentatively the three sets of reactions outlined above are current in the literature treating of sulfide oxidation and enrichment. Others have been supplied by the writer to complete what may be called natural or obvious sequences. It is believed that no one of the equations presented contemplates the concomitance of bodies that are chemically incompatible.

*Group I.* Intermediate equations and final equation representing reactions in the upper zone of complete oxidation:

$$FeS_2 + 6O = FeSO_4 + SO_2 \quad (1)$$
$$FeS_2 + H_2O + 7O = FeSO_4 + H_2SO_4 \quad (2)$$
$$2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O \quad (3)$$
$$2FeS_2 + H_2O + 15O = Fe_2(SO_4)_3 + H_2SO_4 \quad (4)$$ [6]

*Group II.* Intermediate equations and final equation indicating oxidation of pyrite by ferric sulfate. This salt is one of the soluble products indicated by equation(4):

$$FeS_2 + Fe_2(SO_4)_3 = 3FeSO_4 + 2S \quad (5)$$
$$S + Fe_2(SO_4)_3 = 2FeSO_4 + 2SO_2 \quad (6)$$
$$SO_2 + 2H_2O + Fe_2(SO_4)_3 = 2FeSO_4 + 2H_2SO_4 \quad (7)$$
$$FeS_2 + 8H_2O + 7Fe_2(SO_4)_3 = 15FeSO_4 + 8H_2SO_4 \quad (8)$$ [7]

To this group of equations may be added one representing the decomposition of chalcocite and the simultaneous reduction of ferric sulfate:

[6] Derived from equations (2) and (3) by substitution. Where chalcopyrite is present a corresponding equation will indicate the formation of $CuSO_4$ instead of $H_2SO_4$.

[7] Derived from the foregoing equations. Note that(8) is strictly comparable with (4).

$$Cu_2S + 2Fe(SO_4)_3 = 4FeSO_4 + S + 2CuSO_4$$

*Group III.* Intermediate equations and final equation indicating the last stage of pyrite oxidation where cupric sulfate is the reagent, and chalcocite a side product:

$$2FeS_2 + 2CuSO_4 = Cu_2S + 2FeSO_4 + 3S \qquad (9)$$

$$3S + 2CuSO_4 = Cu_2S + 4SO_2 \qquad (10)$$

$$5SO_2 + 6H_2O + 2CuSO_4 = Cu_2S + 6H_2SO_4 \qquad (11)$$

$$5FeS_2 + 14CuSO_4 + 12H_2O = 7Cu_2S + 5FeSO_4 + 12H_2SO_4 \qquad (12)$$ [8]

Equations analogous to (12) but involving chalcopyrite and sphalerite in place of pyrite are the following:

$$5CuFeS_2 + 11CuSO_4 + 8H_2O = 8Cu_2S + 5FeSO_4 + 8H_2SO_4 \qquad (13)$$

$$5ZnS + 8CuSO_4 + 4H_2O = 4Cu_2S + 5ZnSO_4 + 4H_2SO_4 \qquad (14)$$

Here, in the interest of completeness, may be introduced the Stokes equation representing the change pyrite to covellite, and the analogous equation involving chalcopyrite:

$$4FeS_2 + 7CuSO_4 + 4H_2O = 7CuS + 4FeSO_4 + 4H_2SO_4 \qquad (15)$$ [9]

$$CuFeS_2 + CuSO_4 = 2CuS + FeSO_4 \qquad (16)$$

It is to be noted that equation (5) which is given by Stokes[10] is stated by him to conform with the observation that on exposure to the air, pyrite yields free sulfur which may be detected by extraction with ether. Also equation (6) conforms with the results of experimental oxidation of pyrite by H. N. Winchell[11] and is in accord with observation as recorded by Gottschalk and Buehler.[12]

Of the expressions under Group III, equations (9) and (10) are seen to be analogous to equations (5) and (6), and if the latter are real it may be thought likely that the former are. In any event it is almost obvious that equations (9) to (11) were used

[8] Derived from the foregoing equations. This expression, which is to be credited to Stokes, was first printed in the work of Lindgren already cited (p. 183.) where the reader is led to infer that the equation was tested by quantitative determination of the $H_2SO_4$ formed. See also Stokes, Economic Geology, **2**: 22, 1907.

[9] Stokes, H. N., loc. cit.

[10] U. S. Geol. Survey Bull. 186, pp. 15 and 19, 1901.

[11] Loc. cit.

[12] Economic Geology **7**: 16, 1912.

by Stokes in deducing equation (12), and it is perhaps sufficiently accurate to regard this chemist as their sponsor. As equation (10) is to this extent plausible it may be suggested, not inappropriately, as offering a link between the two lines of investigation due to Winchell and Tolman on the one hand and to Stokes on the other. Equation (10) shows at least the possibility that $SO_2$ may be a product of chemical reaction during the final stage of oxidation as well as during earlier stages; or, in other words, it indicates that $SO_2$ may be evolved in the situs of chalcocite deposition as well as in those situations where ferric sulfate undergoes reduction, as suggested by equation (6), or where free oxygen is being used as in equation (1). In this manner it may be possible to avoid the objection raised by Lindgren.

Although the principal object of the present communication is attained in a tentative reconciliation of the suggestion due to Winchell with the points urged against it by Lindgren, occasion may be taken to present certain additional considerations pertaining to the Stokes equation and analogous expressions.

If the equations given are accepted as affording a working hypothesis, it might be found that under experimental conditions the attack of cupric sulfate on pyrite, or preferably on chalcopyrite, could be initiated in the presence of a moderate amount of $SO_2$ and that when thus started the conversion might continue without further aid, proper environment being maintained by the presence of $SO_2$ currently evolved. There are good reasons for the statement that chalcopyrite is less stable than pyrite in solutions containing salts of copper. For the deposition of chalcocite, the chemical mechanism involved must be essentially identical in either case.

When the pyrite and chalcopyrite equations are compared with respect to volume relations, in the conversion to chalcocite by molecular replacement the former is found to demand expansion in the ratio 2 : 3, while the latter requires little if any volume increase. Accepting both equations, we might anticipate that pyrite would prove to be a less efficient agent than chalcopyrite in chalcocite deposition. In the porphyry ore at Ely, Nevada, where grains of primary chalcopyrite and pyrite occur side by side the former are always more deeply coated with chalcocite

than the latter and usually the ratio of film thicknesses is greater than 3 : 1. The suggested explanation is that replacement continues only so long as space can be found for the necessary expansion, so that where pyrite is the core mineral for chalcocite deposition reaction would be inhibited much sooner than where chalcopyrite is the nucleus.

Essentially the same volume relations appear in using the simplest possible expressions for complete reaction between cupric sulfate and pyrite or chalcopyrite when the product is covellite—equations (15) and (16). It seems safe to predict, therefore, that chalcopyrite will be shown to be a more favorable nucleus than pyrite for receiving secondary covellite.

The volume relations required by equation (14) show no essential change, if sphalerite is transformed into chalcocite—that is the ratio is nearly 1 : 1, a slight expansion being found by calculation. On the other hand, when sphalerite is converted to covellite, if the reaction goes on molecularly according to the simplest equation which may be written, there is a diminution of volume in the ratio 12 : 11. Other things being equal, it would seem that volume relations favor the deposition of covellite rather than chalcocite where sphalerite comes into contact with copper sulfate solution.

Altho the equations which have been given as a basis for the foregoing discussions are speculative, it is hoped that the systematic arrangement here presented may hasten experimental work which is needed before the chalcocite problem can be solved.

## MINERALOGY.—*Immense bloedite crystals.* Preliminary note.

WALDEMAR T. SCHALLER, Geological Survey.

A recent find of bloedite by Mr. Hoyt S. Gale of the Geological Survey, is remarkable for the immense size of the crystals. An extensive deposit of soda forms a crust on Soda Lake, in Carriso Plain, San Luis Obispo County, California. This deposit has been described by Arnold and Johnson[1] who give a detailed analysis of the saline crust which shows it to be a nearly pure sodium

[1] Bull. 380, U. S. Geological Survey, p. 369. 1908.

sulfate with 1.66 per cent MgO. In the black mud below this crust were found the isolated crystals of bloedite—a hydrous magnesium-sodium sulfate with 12 per cent MgO.

The larger crystals have a dark almost black appearance when the superficial covering of grey mud is removed tho the smaller crystals are nearly colorless, the black appearance being due to impurities. In places the larger crystals are likewise nearly colorless and translucent and in small pieces transparent. In fact, selected fragments are clear and glassy and together with the lack of cleavage, greatly resemble quartz fragments.

The largest crystal at present on hand measures 16½ cm. (6½ inches) by 10½ cm. by 3½ cm. and weighs 652 grams. The crystals are flattened somewhat parallel to the base and show the following forms:

Large.......................................... $c(001)$, $d(011)$, $m(110)$
Medium.......................................... $n(210)$, $p(111)$
Small.......................................... $q(\bar{2}01)$, $s(\bar{2}11)$, $u(\bar{1}11)$, $x(\bar{1}21)$

The measurements were made with a contact goniometer and gave the following results:

| FORM | MEASURED | CALCULATED |
|---|---|---|
| $m(110) : p(111)$ | 47° | 46° 42′ |
| $c(001) : q(\bar{2}01)$ | 50 | 50 06 |
| $c(001) : p(111)$ | 36 | 36 55 |
| $n(210) : n'''(2\bar{1}0)$ | 68 | 67 06 |
| $m(110) : m'''(1\bar{1}0)$ | 105 | 105 58 |
| $d(011) : d'(0\bar{1}1)$ | 67 | 66 46 |
| $c(001) : s(\bar{2}11)$ | 55 | 55 16½ |
| $c(001) : u(\bar{1}11)$ | 43 | 42 05 |

The form $x(\bar{1}21)$ was determined by zonal relations.

An analysis of selected pure material gave the following:

*Analysis of bloedite from California*

| | |
|---|---|
| $H_2O$ | 21.37 |
| $MgO$ | 11.93 |
| $Na_2O$ | 18.26 |
| $SO_3$ | 48.11 |
| | 99.67 |

These proportions are close to those required by the formula $Na_2Mg(SO_4)_2.4H_2O$.

PHYSIOLOGICAL BOTANY.—*The formation of leafmold.*[1]
FREDERICK V. COVILLE, Department of Agriculture.

When the leaves of a tree fall to the ground they begin to decay and ultimately they are disintegrated and their substance becomes incorporated with the other elements of the soil. The same thing happens with the leaves, stems, and roots of herbaceous plants. Such organic matter is one of the chief sources of food for plants, and its presence in the soil is therefore of fundamental importance in the maintenance of the vegetative mantle of the earth.

In a series of experiments from 1906 to 1910 the speaker showed that a condition of acidity is a primary requirement of the blueberry, laurel, trailing arbutus, and other plants associated with them in natural distribution. Other kinds of plants and plant associations require on the contrary a neutral or alkaline soil.

It is the purpose of the present address to show how the leaves of trees in the process of the formation of leafmold produce at one time or under one set of circumstances a condition of soil acidity, at another time or under other circumstances a condition of alkalinity, and since the acidity of the soil is a fundamental factor in plant ecology, to point out that a knowledge of certain phenomena in the decay of leaves is essential to a correct understanding of the distribution of vegetation over the surface of the earth and its adaptation to the uses of man.

In the early experiments with blueberries it had been found that these plants grew successfully in certain acid soils composed chiefly of partially rotted oak leaves. On the rather natural assumption that the more thoro the decomposition of this material the more luxuriant would be the growth of the blueberry plants, some old oak leafmold was secured for further experiments. It had been rotting for about five years and all evidences of leaf structure had disappeared. It had become a black mellow vegetal mold.

When blueberry plants were placed in mixtures containing this mold they did not respond with luxuriant growth. On the

[1] Address of the retiring President, Washington Academy of Sciences, presented at the annual meeting of the Academy, January 16, 1913.

contrary their leaves turned purple and afterward yellowish, their growth dwindled to almost nothing, and at the end of the season when compared with other blueberry plants grown in a soil mixture in which the oak leafmold was replaced by only partially decomposed oak leaves the plants in the oak leafmold were found to weigh only one-fifth as much as the others. This astonishing result is exactly contrary to the ordinary conception. We have been accustomed to believe that the more thoroly decomposed the organic matter of a soil the more luxuriant its vegetation. In this case, however, thoro decomposition of the soil was exceedingly injurious to the plants.

This remarkable difference in effect between partially decomposed and thoroly decomposed oak leaves was found to be correlated with a difference in the chemical reaction of the two materials, the partially decomposed oak leaves being acid, when tested with phenolphthalein, and the oak leafmold alkaline.

With rose cuttings and alfalfa seedlings in the same two soils exactly opposite results followed, those in the oak leafmold making a luxuriant growth, those in the partially decomposed oak leaves showing every sign of starvation.

Every botanist is familiar with the rich woods where trillium, spring beauty, mertensia, and bloodroot delight to grow, in a black mellow mold made up chiefly of rotted leaves. He is familiar too with the sandy pine and oak woods where grow huckleberries, laurel, princess pine, the pink lady's slipper, and trailing arbutus. The soil here also is made up chiefly of rotting leaves and roots. Yet one does not look for trilliums in laurel thickets, or for arbutus among the bloodroots. Either habitat is utterly repugnant to the plants of the other.

Tests of the two habitats show that the trillium soil is alkaline, the other acid, reactions corresponding exactly to those observed in the cultural experiments already described, rose cuttings and alfalfa requiring an alkaline soil, blueberries an acid soil. The difference is as conspicuous in nature as in the laboratory and the greenhouse. What are the conditions under which rotting leaves develop these opposite chemical reactions?

In a ravine in the Arlington National Cemetery, near Washing-

ton, where the autumn leaf fall from an oak grove has been dumped year after year for many years, every stage in the decomposition of oak leaves may be observed, from the first softening of the dry brown leaf by rain to the black mellow leafmold in which all traces of leaf structure have disappeared. When freshly fallen the leaves show 0.4 normal acidity.[2] Those not familiar with the chemical expression "normal acidity" may perhaps most readily understand the term by reference to ordinary lemon juice, which has very nearly normal acidity in the chemical sense. Fresh oak leaves may be conceived therefore as having about one-third the acidity of lemon juice, gram to cubic centimeter. From a soil standpoint such a degree of acidity is exceedingly high. Probably no tree or flowering plant could live if its roots were imbedded in a soil as acid as this. A correct appreciation of the excessive acidity of freshly fallen leaves enables one to understand why it is that the leaves of our lawn trees, if allowed to lie and leach upon the grass, either injure or destroy it. On such neglected lawns the turf grows thin, mossy, and starved.

From the height of their initial acidity it is a long descending course thru the various stages of leaf decomposition to the point of chemical neutrality, and then upward a lesser distance on the hill of alkalinity, in the black leafmold stage.

In order to ascertain the rate of decomposition in leaves of various kinds, observations were begun in the autumn of 1909 on leaves of silver maple, sugar maple, red oak, and Virginia pine, exposed to the weather in barrels and in concrete pits. In one experiment a mass of trodden silver maple leaves 2 feet in depth, with an initial acidity of 0.92 normal, was reduced in a single year to a 3-inch layer of black mold containing only a few fragments of leaf skeletons and giving an alkaline reaction. In these experiments sugar maple leaves have shown a slower rate of decomposition than those of silver maple, while red oak leaves still show an acidity of 0.010 normal after three years of exposure,

[2] For a description of the method followed in determining the acidity see Coville, 1910, p. 27. Experiments in blueberry culture. Bulletin 193, Bureau of Plant Industry, U. S. Dept. Agri.

and leaves of Virginia pine an acidity of 0.055 normal under the same conditions.

The alkalinity of leafmold is due chiefly to the lime it contains, the lime content expressed in terms of calcium oxid often reaching 2 to 3 per cent of the dry weight. One sample had a lime content of 3.55 per cent. Many of the soils that result directly and exclusively from the decomposition of limestone have a lower percentage of lime than this. An alkaline leafmold containing 2 to 3 per cent of lime is properly regarded as a highly calcareous soil. Yet such a deposit may be formed in a region where the underlying soil is distinctly noncalcareous, the lime content of the soil being only a small fraction of 1 per cent and the soil reaction being acid. Whence comes the abundance of lime in an alkaline, richly calcareous leafmold formed over a soil distinguished by an actual poverty of calcareous matter?

If the leafmold is rich in lime the leaves from which it is derived should also be rich in lime. A determination of the amount of calcium oxid in the dried freshly fallen leaves of some of our well known trees shows this to be true, as illustrated by the following selections:

| *Kind of leaves* | *Per cent of calcium oxid* |
|---|---|
| Red oak (*Quercus rubra*) | 1.73 |
| Silver maple (*Acer saccharinum*) | 1.88 |
| Pin oak (*Quercus palustris*) | 1.91 |
| Sweet gum (*Liquidambar styraciflua*) | 1.92 |
| Bur oak (*Quercus macrocarpa*) | 2.39 |
| Sugar maple (*Acer saccharum*) | 2.56 |
| Tulip tree (*Liriodendron tulipifera*) | 2.84 |
| Hickory (*Hicoria myristicaeformis*) | 3.66 |
| Gingko (*Ginkgo biloba*) | 4.38 |

It should be understood that the lime thus shown does not exist in the leaf in the form of actual calcium oxid. It is largely combined with the acids of the leaf and serves in part to neutralize them, but is insufficient in amount to effect a complete neutralization. In all the kinds of leaves and herbage thus far examined, the net result is an acid condition altho lime may be present in large amount. Thus in the leaves of silver maple a condition of excessive acidity exists, about 0.9 normal, notwithstanding the presence of nearly 2 per cent of lime.

As the decomposition of such leaves progresses the acid substances are disorganized and largely dissipated in the form of gases and liquids, while the lime being, only slightly soluble remains with the residue of decomposition, the black leafmold, and renders it alkaline.

In soils poor in lime, trees and other plants constituting the vegetative mantle of the earth may be regarded as machines for concentrating lime at the surface of the ground. This lime is drawn up by the roots in dilute solution from lower depths, is concentrated in the foliage, and the concentrate is transferred to the ground by the fall and decomposition of the leaves. The proverbial agricultural fertility of the virgin timberlands of our country was undoubtedly due in large part to the lime accumulated on the forest floor by the trees in preceding centuries, and to the consequent alkalinity of such surface soils when the timber had been removed and the leaf litter was thoroly decomposed. After a generation or two of reckless removal of crops the surface accumulation of lime was depleted and unless the underlying soil was naturally calcareous a condition of infertility ensued which for the purposes of ordinary agriculture could be remedied only by the artificial application of lime.

The chief agents in the decay of leaves are undoubtedly fungi and bacteria. There are other agencies, however, that contribute greatly to the rapidity of decay. Important among these are earthworms, larvae of flies and beetles, and myriapods or thousand-legged worms. Animals of all these groups exist in myriads in the leaf litter. They eat the leaves, grind them, partially decompose them in the process of digestion, and restore them again to the soil, well prepared for the further decomposing action of the microscopic organisms of decay.

The importance of earthworms in hastening the decay of vegetal matter was pointed out long ago by Darwin in his classical studies on that subject. The importance of myriapods, however, as contributing to the formation of leafmold has not been adequately recognized. In the canyon of the Potomac River, above Washington, on the steeper forested talus slopes, especially those facing northward, the formation of alkaline leafmold is in active

progress. The purer deposits are found in pockets among the rocks, where the leafmold is not in contact with the mineral soil and does not become mixed with it. The slope directly opposite Plummer's Island is a good example of such localities. Here during all the warm months the fallen leaves of the mixed hardwood forest are occupied by an army of myriapods, the largest and most abundant being a species known as *Spirobolus marginatus*. The adults are about 3 inches in length and a quarter of an inch in diameter. They remain underneath the leaves in the day time and emerge in great numbers at night. On one occasion a thousand were picked up, by Mr. H. S. Barber, on an area 10 by 100 feet, without disturbing the leaves. On another occasion an area 4 by 20 feet yielded 320 of these myriapods, the leaf litter in this case being carefully searched. Everywhere are evidences of the activity of these animals in the deposits of ground up leaves and rotten wood. Careful measurements of the work of the animals in captivity show that the excrement of the adults amounts to about half a cubic centimeter each per day. It is estimated on the basis of the moist weight of the material that these animals are contributing each year to the formation of leafmold at the rate of more than two tons per acre.

The decay of leaves is greatly accelerated also when the underlying soil is calcareous and alkaline, it being immaterial whether the lime is derived from a limestone formation or is a concentrate of the vegetation. On the rich bottomland islands of the upper Potomac the autumn leaf fall barely lasts thru the following summer, so rapid is its decay. These bottomlands have an alkaline flora, and they are found to have an alkaline reaction, caused by the lime brought to them in the flood waters.

The acceleration of leaf decay by an alkaline substratum is due to the prompt neutralization of the acid leachings of the leaves and also to the fact that such a substratum harbors with great efficiency many of the most active organisms of decay, from bacteria to earthworms.

It must not be understood that in a state of nature the decomposition of leaves is always so simple and uniform a process as has been described, or that it always results in the formation of

an alkaline leafmold. The chief factors that contribute to the acceleration of leaf decay have already been enumerated, but there are other conditions of nature that obstruct and retard this process. Under certain conditions the progress of decomposition may be permanently suspended long before the alkaline stage is reached. The soils thus formed, altho high in humus like a true leafmold, have an acid reaction and a wholly different flora.

Examples of such suspensions of leaf decay are found in bogs, where the deposited vegetation is protected from the organisms of decay by submergence in non-alkaline water, and on uplands where the soil is derived from sand, sandstone, granite, or schist, in which there is not enough lime or other basic material to neutralize the acidity of the decaying leaves.

There is of course a supply of lime in the leaves themselves, and as a new layer of leaves is added to the soil each year it might be expected that there would result an unlimited concentration of lime in the surface soil and that all surface soils that supported a growth of vegetation would ultimately become alkaline. Such an indefinite accumulation of lime is prevented, however, by another factor which requires consideration. As soon as each successive layer of leaf litter is sufficiently decayed to permit the roots of plants to enter it and feed upon it, the lime it contains, together with other mineral constituents, begins to be absorbed. This loss of lime from the decaying leaves is sufficient, under many situations in nature, to prevent the decaying mass from reaching the alkaline stage. Decomposition is suspended while the leaf litter is still acid. True leafmold, with an alkaline reaction, is never formed under such conditions. The leaf deposit remains permanently acid and such areas bear an acid flora. In the vicinity of Washington one often sees hills of quartz gravel, wind-swept and rain-washed, where the soil contained little lime in the beginning, and none could be brought by flood waters or by the dust of the atmosphere. Characteristic plants of such hills are black jack oak, trailing arbutus, wild pansy, azalea, and huckleberry, all plants adapted to acute conditions of acidity. If one's front yard happens to coincide with

what was once such a spot, let him not undertake the herculean task of growing roses and a bluegrass turf. Let his lawn be of redtop and his shrubs be azaleas, laurel, and rhododendrons.

Another factor that contributes to the suspension of leaf decomposition is the acid leachings from each new deposit of autumn leaves. Various acidity determinations show that after lying exposed to the weather over winter, leaves ordinarily have only one-fifth to one-tenth the acidity they possessed when they fell to the ground. It has been found experimentally that the leachings from fresh leaves will serve to acidulate an underlying soil of moderate alkalinity. Unless therefore the conditions of a locality are such as to effect the decomposition of one year's leaf fall before the next year's deposit takes place, a permanent acid leaf cover is established. In many of the oak forests on the sandy coastal plain eastward from Washington there is a permanent accumulation of such material. The roots of the trees and undershrubs bind the half-rotted leaves into a dense mat. The principal trees are oaks. The principal shrubs that make up the dense underbrush belong to the Ericaceae and related families. There is no mellow leafmold nor any of the leafmold plants.

This kind of mat or turf is of such widespread occurrence, is so distinct in its appearance, and so characteristic in the type of vegetation it supports that it should have a name of its own, in order that it may come to be recognized as one of the important phenomena of nature.

Because if its resemblance to bog peat in appearance, structure, and chemical composition, and because it supports a type of vegetation similar to that of bog peat, it has been proposed to adopt for it the name upland peat. As defined in an earlier publication[3] upland peat is "a nonpaludose deposit of organic matter, chiefly leaves, in a condition of suspended and imperfect decomposition and still showing its original leaf structure, the suspension of decomposition being due to the development and maintenance of an acid condition which is inimical to the growth of the micro-organisms of decay."

[3] Coville, 1910, p. 34. Experiments in blueberry culture. Bulletin 193, Bureau of Plant Industry, U. S. Dept. Agri.

Upland peat would have become leafmold had not the orderly normal course of leaf decomposition been suspended and conditions of acidity established which rendered the further progress of that decomposition impossible.

The rate at which leaves decay is greatly influenced by temperature. In the cooler northern latitudes and at high elevations in lower latitudes the rate of decay is slower and the formation of upland peat is more general than in warmer climates. Except on calcareous soils the higher Apalachian peaks, from 4000 to 6000 feet, bear an almost continuous layer of upland peat, from a few inches to a foot or more in depth. Their great rhododendron thickets are rooted in deep beds of upland peat. The spruce forests of the higher New England mountains lay down a similar formation.

In the treeless west the decay of leaves where it is not actually suspended by dryness is rapid and complete. At the higher elevations, however, where the land begins to be timbered the organic matter does not fully decay, and in the heavily timbered areas the deposit of upland peat often becomes characteristically deep and continuous. In fighting creeping fires in the yellow pine forests at the lower elevations the favorite and most effective tool is the rake, which parts the light leaf litter and puts a stop to the progress of the flames. But in the dense fir and spruce timber the forest ranger's chief tools are the spade and the mattock, with which he must cut through the thick layer of dry peat to the mineral soil beneath if he is to effectually combat a slowly creeping fire.

So strong is the tendency to the formation of peat under the low temperatures and heavy precipitation of the high mountains that even on limestone soils a superficial layer of upland peat is sometimes accumulated. Such a condition exists on innumerable areas at an elevation of about 10,000 feet in the Manti National Forest of Utah. On the basaltic plateau of extreme northeastern Oregon, where the soil is naturally alkaline in reaction the lodgepole pine and Douglas fir forests at elevations of 5000 feet and over lay down a continuous bed of peat which supports a characteristic acid flora. A quantitative test of one of

the acid flora soils of this region, at an elevation of 8000 feet, showed the customary high acidity at the surface, and successively lower degrees of acidity underneath, until at the depth of 5 feet, at the surface of the basaltic rock, the reaction was neutral.

The group of plants that forms the best index to the acid character of a soil is the family Ericaceae, and the related families Vacciniaceae and Pyrolaceae. When these occur in vigorous growth on a calcareous soil or among calcareous rocks, as is sometimes reported, one may expect to find, as the speaker in his own experience has always found, that a layer of upland peat has been formed above the calcareous substratum and that in this superficial layer the roots of the plants find their nourishment, really in an acid medium, notwithstanding the alkalinity beneath.

Continued observations on the association of certain types of wild plants with acid and non-acid soils, supported by cultural experiments, are in all respects confirmatory of the theory that soil acidity is one of the most influential factors in plant distribution and plant ecology.

The relation of leafmold to the existence of acid or non-acid soil conditions may now be viewed with appreciative recognition. If the conditions in any area are such that the decay of leaves follows the uninterrupted course that leads to the formation of leafmold a state of soil alkalinity is reached, with all the resultant effects on the growth and distribution of the native vegetation. If on the other hand the conditions are such that the course of decay is diverted into the channel that ends in the formation of peat, a condition of permanent acidity is indicated, with the accompaniment of all those peculiar plant phenomena which are characteristic of such a state.

It is perhaps desirable to call attention here to the fact that while partially decomposed vegetation appears to be the chief source of soil acidity there are mineral constituents of the soil, of wide distribution and great abundance, which are also acid in reaction. The acidity of which we hear so much in agricultural writings as characteristic of soils worn out by long years of careless farming is doubtless due in large part to a natural mineral acidity unsheathed by the removal of the lime that once neutralized

it for like the leaves of trees many of the crops of agriculture are heavy with lime and their uncompensated removal year after year has its inevitable cumulative result.

The speaker hopes that he does not overstep the proper bounds of this address if he calls attention to conditions in bog deposits which almost exactly parallel the two types of terrestrial organic formation, leafmold and upland peat. In bogs with alkaline waters, as for example those underlain by marl, a condition of permanent acidity is not maintained in the lower strata of the deposit. As far upward as the alkaline waters penetrate, the antiseptic acids are not present, decay continues, and the resulting formation is not peat, but a plastic fine-grained black material that may best, perhaps, be designated by that much misused term muck. Muck corresponds in bog deposits to leafmold in upland deposits, contrasting with bog peat as leafmold contrasts with upland peat.

We may follow this idea one step further. Coal is petrified peat. As the purest peats are not formed in alkaline waters, it can not be expected that the best coal will be found in situations indicative of alkaline conditions. If coal is found immediately overlying beds of marl or limestone it is to be expected that such coal will be of an impure type corresponding in origin to muck. The speaker takes the liberty of suggesting to his geological friends that in reconstructing in theory the climatic and other conditions under which the various kinds of coal were deposited they may safely hypothesize that the purer coals were laid down in waters that were acid.

Allusion has been made to the peculiar characteristics of plants that inhabit peat. Among these peculiarities perhaps none is more remarkable than the presence of mycorhizal fungi on the roots of many, perhaps most, peat-loving plants. It is known that peat is very poorly supplied with nitrogen in the form of nitrates, which most plants of alkaline soils appear to require. Organic nitrogen, however, is abundant in peat and there is very strong evidence that these mycorhizal fungi take up this organic nitrogen, and possibly atmospheric nitrogen also, and transfer it in some acceptable form to the plants in whose roots

they live. Unfortunately the work of botanists on these fungi has been confined largely to the determination of the mere anatomical fact of their occurrence on the roots or in certain of the root cells, with descriptions of their size and configuration. Little attention has been paid to the isolation of the fungi, their culture and identification, or to the demonstration of their physiological action. The only hypothesis, however, that satisfactorily explains what we already know about the mycorhizal fungi is that they prevent the nitrogen starvation of peat-inhabiting plants. It is well known that certain peat-bog plants, as for example sundew, trap insects, digest them, and assimilate their nitrogen. It is to be hoped that within a few years we shall be equally well informed about the function of the mycorhizal fungi. But even now we may speak of their probable function with confidence.

The mycorhizal fungi are known to occur on most of the trees that inhabit acid situations, for example chestnut, beech, oaks, and conifers. The ordinary hillside pasture in New England is a mycorhizal cosmos. The clubmosses have them, the sweet fern, the blueberries, the ferns, the orchids. In our sandy pine and oak woods about Washington almost all the vegetation possesses mycorhizal fungi. One comes to think of the giant oaks as dependent on these minute organisms.

Were Solomon to write a new edition of the Proverbs today I am sure that he would tell us "There be four things which are little upon the earth, but they are exceeding strong," and that among the four he would include "The little brothers of the forest, they seek not the light but the leafy earth; they prepare for the oak the strength that is his."

Our American agriculture, derived in the main from the agriculture of the Mediterranean region, and that in turn from the older agriculture of Persia, is chiefly made up of plants that thrive best in alkaline or neutral soils. Altho many of our soils in the eastern United States are naturally acid we try with only indifferent success to grow in them these alkaline plants of southern Europe and the East. Altho some of our agricultural plants are tolerant of acidity, our agriculturists have not yet recognized the possibility of building up for acid soils a special agriculture

in which all the crops are acid-tolerant. We may yet, perhaps, utilize for agricultural purposes even the sandy acid lands of the coastal plain instead of turning them over as we now do to the lank huckleberry picker, whose lonesome garden is all that he is able to reclaim by present methods from the imaginary wilderness that surrounds him. Yet these lands contain all sorts of delicious native fruits, and a natural vegetation rich and luxuriant after its own manner.

Had our agriculture originated not in the alkaline soils of the Orient but among the aboriginal peoples of the bogs of Scotland or of the sandy pine barrens of our Atlantic Coastal Plain we should have entirely different ideas of soil fertility from those we now possess. If our cultivated fruits were large and otherwise improved forms of the blueberry, the service berry, the thornapple, and the beach plum, if our only grains were rye and buckwheat and our only hay redtop and vetch, and if our root crops consisted of potatoes, carrots, and onions, our high-priced agricultural lands would be the light sandy acid soils and the drained bogs, while our deep limestone soils would be condemned to use for the pasturage of cattle and of sheep.

Thus far man has devoted himself largely to the utilization of the plants of the leafmold, which have gathered up for him the wealth of the earth. Let him now, I say, turn his attention also to the plants of the peat and try whether they will not yield to him in increased measure the luxuriance of foliage and of fruit that they have always yielded without assistance to nature herself.

## ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

PHYSICAL CHEMISTRY.—*The binary system*: $Na_2Al_2Si_2O_8$ (*nephelite, carnegieite*)—$CaAl_2Si_2O_8$ (*anorthite*). N. L. BOWEN. American Journal of Science, **33**: 551–573. 1912.

The study of the system $Na_2Al_2Si_2O_8 - CaAl_2Si_2O_8$ was undertaken because of the importance of these compounds as rock-forming constituents. It was found that the soda compound exhibits enantiotropism with the inversion point at 1248°. The low temperature form (nephelite) crystallizes in the hexagonal system with a habit similar to that of natural nephelite. The high-temperature form is triclinic. It has no natural analogue and has been given the name carnegieite. Carnegieite melts at 1526°.

The lime compound occurs only in the triclinic form, anorthite, and melts at 1550°.

Both carnegieite and nephelite are capable of holding the lime compound in solid solution, the former 5 per cent and the latter as much as 35 per cent.

The effect of solid solution on the inversion-point was well shown by the system. The temperature of inversion rises considerably as the amount of the lime compound in solid solution increases.

The optical constants of the components were carefully determined. Crystals of the artificial nephelite were measured on the goniometer and their hexagonal nature confirmed. It was especially gratifying to be able to determine definitely the variation, with composition, of the optical properties of the hexagonal mix-crystals (nephelite). With increasing proportion of the lime molecule the birefringence of 0.004 (negative) becomes less, passes through zero, and finally becomes 0.002 (positive).

The problem as a whole, although in some measure complicated, was found capable of very definite laboratory solution. The extension of the study to include the potassium-bearing nephelites has already been begun. N. L. B.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

A special meeting of the Anthropological Society of Washington was held January 7, 1913, in the National Museum, with the President, Mr. George R. Stetson in the chair.

Mr. E. Dana Durand, Director of the Census read a paper on *Race statistics of the last census*. During the decade 1900–1910 the white population of the United States increased about 22 per cent and the negro about 11 per cent. This difference is partly due, however, to the direct or indirect effect of immigration of whites, in the absence of which the whites would have increased about 14 per cent. The Indians increased about 12 per cent, the Chinese decreased in number, while the Japanese nearly trebled. The whites have at practically every census shown a more rapid rate of increase than the negroes, and there is reason to believe that the difference between the two races in rate of increase from 1890 to 1900 was greater than appeared from the census returns, on account of a probable underenumeration of the negroes in 1890. The census of 1910 showed that about 21 per cent of the negroes are mulattoes, as compared with about 12 per cent in 1870, the last preceding census at which the question regarding blood mixture was asked in comparable form.

There has been no very great migration of negroes out of the South, nearly nine-tenths of the total number being still found in that section. The number living outside the South increased 167,000 between 1900 and 1910, while the number residing in the South increased over 800,000. The rate of natural increase—that is, by excess of births over deaths—of the white population of the South, however, is much higher than that of the negroes, being higher also than that of the whites in the North.

Among the native white population whose parents were born in this country, there were, in 1910, 104 males to each 100 females, as compared with only 98.9 in the case of the negroes. Among all classes of the population more boy babies than girl babies are born, but equality tends to be brought about by a higher death rate among the males. The difference in sex distribution between the whites and the negroes is probably attributable, in part at least, to more favorable health conditions among the whites.

The age distribution of the native white population is somewhat different from that of the negroes, probably chiefly on account of a lower death rate among whites, tending to greater longevity. There has apparently been a very marked decline in the birth rate among negroes in recent years, while there had been a gradual but less marked decline in the birth rate of the whites during each decade for a long period of time.

Negroes tend to marry earlier than the native white classes; and, in fact, at all age periods the proportion of married, widowed, and divorced persons, taken together, is higher in the case of the negroes of both sexes than in the case of the native whites of native parentage.

There has been a marked change in the composition of the foreign-born population of the United States during recent years. Natives of northwestern Europe constituted more than two-thirds of the total foreign-born population of the United States in 1900, but less than half in 1910, while southern and eastern Europeans formed only a little over one-sixth of the total at the earlier census, as compared with three-eights in 1910. The Germans and the Irish particularly have fallen off conspicuously in numbers, while the natives of Russia—largely Russian Jews and Poles—Austria, Hungary, Italy, Greece, and other countries of southern and eastern Europe have increased by very high percentages, no lesss than 1090 per cent in the case of natives of Greece. The natives of Russia now rank second among the foreign-born classes, and those of Italy fourth.

Various inquiries, accompanied by additional statements of facts and explanations, were answered by Mr. Durand, but there was no discussion beyond these. WM. H. BABCOCK, *Secretary.*

## THE BOTANICAL SOCIETY OF WASHINGTON

The 12th annual business meeting was held on Wednesday, October 30, 1912. Officers were elected as follows: President, W. W. STOCKBERGER; Vice-President, C. R. BALL; Recording Secretary, H. L. SHANTZ; Corresponding Secretary, C. L. SHEAR; Treasurer, F. L. LEWTON.

The executive committee reported an active membership of 108.

The 83rd regular meeting was held at the Cosmos Club November 12, 1912. The following papers were read:

*A portrait of Linnaeus:* Dr. J. N. ROSE. Doctor Rose exhibited an engraved portrait of Linnaeus which had recently been presented to the Smithsonian Institution by Captain John Donnel Smith, of Baltimore who had previously given to that Institution his magnificent herbarium and library. This portrait is one rarely seen in this country, being a mezzotint of one of the earliest portraits of Linnaeus, the original being a replica of Hoffman's famous picture showing Linnaeus in Lapland dress, of which the original is now the property of the Clifford family. This replica was known to have been in the possession of one Thornton as late as 1811; but its whereabouts now is not known.

Doctor Rose also called attention to the large collection of portraits of Linnaeus in the possession of the Linnean Society, and also to the work of Tycho Tullberg, "Linne-porträtt," a quarto volume of 185 pages with 25 portrait plates.

*Rough-bark disease of the yellow newtown pippin:* Mr. JOHN W. ROBERTS.

*Botanizing in the region of the natural bridges of southern Utah:* Dr. P. A. RYDBERG (by invitation).

C. L. SHEAR, *Corresponding Secretary.*

## THE PROCEEDINGS

### OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str.. Berlin.

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### Abstracts



### Proceedings

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# JOURNAL

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Vol. III, FEBRUARY 19, 1913 No. 4

METEOROLOGY.—*Violent uprushes in cumulus clouds.* W. J. Humphreys, Weather Bureau.

Every observer of clouds is familiar with the peculiar boiling and tumbling of large cumuli, their formation of new heads, and the other evidences they give of rapid motions and confused turbulence. And indeed the violence is much worse than appearances would indicate, if we are to believe the emphatic statements of the few balloonists who have survived the experience of such an aërial maelstrom.

As no such violent uprush is ever found in any other part of the atmosphere, one naturally asks what is there peculiar to the large cumulus cloud that produces this localized or exceptional result. And the answer, tho not obvious, should be indicated by a discussion of the processes involved in the formation of the cloud itself.

Let us assume the temperature of the atmosphere near the surface of the earth to be 30°C. and the relative humidity 42 per cent, and let ordinary vertical convection, resulting from this temperature, obtain up to the base of existing cumulus clouds—substantially the conditions that frequently obtain of summer afternoons.

Under the assumed conditions the temperature in the rising column decreases approximately at the dry-air adiabatic rate of 10°C. per kilometer from the surface of the earth up to the saturation level, 1.5 kilometers in the present case. At this level, however, because of the latent heat set free by condensation, there

is an abrupt change in the temperature gradient. At first it is rather under 5°C. per kilometer, and then as the elevation still further increases and the temperature steadily grows colder, so that less and less moisture condenses out per degree change, it grows greater, with, of course, the adiabatic gradient for dry air, or 10°C. per kilometer, as the limit towards which it approaches.

Now the ordinary summer temperature gradient in the free atmosphere, between the elevations of 1.5 and 8 kilometers, is approximately 6°C. Hence, in the assumed case, the temperature within the rising column will begin to increase above that of the surrounding atmosphere at the same level, as soon as condensation begins, and the temperature difference, together with the resulting buoyancy, will go on increasing with the elevation to a certain maximum and then decrease to a zero difference. In fact the inertia of the rising mass will carry it beyond the equilibrium level to heights where it will be colder and denser than the adjacent air, and from which it therefore must correspondingly fall back until final equilibrium of temperature and density are established.

Seemingly then the real cause of the violent uprush within large cumulus clouds is the difference in temperature between the interior of the clouds themselves and the surrounding atmosphere at the same level, due, as explained, to the change in the temperature gradient caused by the latent heat of condensation.

PHYSICS.—*The high frequency resistances of inductances.* L. W. Austin, U. S. Naval Radio-telegraphic Laboratory. To appear in full in the Bulletin of the Bureau of Standards.

While the high frequency resistance of non-inductive resistances can be easily determined by substitution methods, the determination of high frequency resistance of inductances offers great difficulties. The decrement and half deflection methods,[1] in addition to being difficult to apply when very accurate results are desired, have also the disadvantage of including in the observed resistance all the sources of energy loss in the circuit. The present method, while laborious, seems capable of giving much more exact results than the others mentioned.

[1] Bulletin Bureau of Standards, **9**: 66. 1912.

The principle of the method is briefly the following: Two equal inductance coils are placed in identical oil calorimeters, one coil is heated by a high frequency current and the other by direct. When the calorimeters are both brought to the same temperature in equilibrium with their surroundings, the heat imparted to each per second must be the same. This heat is proportional to $I^2 R$ and the ratios of the resistances of the two coils at the given frequency and for constant current are inversely proportional to the squares of the currents.[2] To compensate for the slight inequalities in the coils and calorimeters, the direct and

TABLE I

Diameter of double silk covered copper wire = 0.04 cm.
Diameter of coils = 8.6 cm.
Turns of wire per centimeter = 18.9

| COIL | LENGTH | TURNS OF WIRE | INDUCTANCE |
|---|---|---|---|
| | *cm.* | | *m.h.* |
| 1 | 0.60 | 11.0 | 0.022 |
| 2 | 1.10 | 20.5 | 0.066 |
| 3 | 1.55 | 29.5 | 0.115 |
| 4 | 2.65 | 50.0 | 0.273 |
| 5 | 3.75 | 70.5 | 0.475 |
| 6 | 5.40 | 102.0 | 0.775 |

high frequency currents are interchanged and the mean values of the ratios of the current squares taken. The high frequency current is produced by a rotary spark gap in an oscillatory circuit coupled loosely to the circuit containing the inductance coil to be measured. The two circuits are brought to resonance at the frequency desired, and the high frequency current thru the inductance, regulated by varying the coupling. The current is read on a non-shunted hot wire ammeter which has been accurately calibrated for high frequencies. The direct current for the other coil is supplied by a storage battery and the final regulation for equilibrium is made in this circuit. Equality of temperature between the two calorimeters is determined by a differential constantan copper thermoelement. The calorimeters are heated to

[2] See J. Zenneck, Elektromag. Schwingungen, p. 415, 1905, and J. A. Fleming, Principles of electric wave telegraphy, p. 124, 1912.

from 20° to 30° above the temperature of the room. The uncertainty of the individual high frequency current readings is approximately one part in fifty. The mean of thirty or more readings is taken as a basis for each calculation. The calorimeters provided with motor driven stirrers are of glass 15 cm. high and 10.8 cm. in diameter and contain sufficient petroleum to cover the coils under experiment. The coils of 0.40 mm. double silk-covered

TABLE II

| COIL 1 | | COIL 2 | | COIL 3 | |
|---|---|---|---|---|---|
| $\lambda$ | R | $\lambda$ | R | $\lambda$ | R |
| *m.* | *ohms* | *m.* | *ohms* | *m.* | *ohms* |
| 360 | 1.45 | 550 | 2.06 | 780 | 2.87 |
| 550 | 1.09 | 780 | 1.59 | 970 | 2.54 |
| 780 | 1.01 | 970 | 1.51 | 1150 | 2.20 |
| 970 | 0.72 | 1150 | 1.40 | 1440 | 2.02 |
| D.C. | 0.42 | 1440 | 1.31 | 1900 | 1.81 |
| | | D.C. | 0.78 | D.C. | 1.12 |
| COIL 4 | | COIL 5 | | COIL 6 | |
| $\lambda$ | R | $\lambda$ | R | $\lambda$ | R |
| *m.* | *ohms* | *m.* | *ohms* | *m.* | *ohms* |
| 780 | 6.60 | 1440 | 7.75 | 1500 | 13.3 |
| 970 | 5.93 | 1900 | 6.55 | 2000 | 11.6 |
| 1440 | 4.65 | 2400 | 6.28 | 2500 | 10.9 |
| 1900 | 4.03 | 2900 | 5.93 | 3000 | 10.4 |
| 2400 | 3.52 | D.C. | 2.68 | 3500 | 9.6 |
| D.C. | 1.90 | | | 4000 | 9.1 |
| | | | | D.C. | 3.88 |

copper wire are wound on glass, and the principal constants are given in Table I and their resistances in Table II.

After the determination of the resistance of the six pairs of standard coils a roller inductance of the Fessenden type was calibrated by comparison with the standard coils. The method used is as follows: A buzzer-driven wave meter is used to excite an oscillatory circuit containing a sensitive thermoelement and variable air condenser. By means of switches either one of the standard coils or the variable inductance can be inserted in this circuit, the deflections in each case being observed on the galvanometer of the thermoelement. Sufficient fine wire resistance is

then placed in series with the inductance giving the larger deflection and adjusted until its deflection is reduced to that of the other inductance. The resistance of the standard coil for the given frequency being known, the corresponding resistance of the variable inductance at this point is at once determined. When the variable inductance has been calibrated in this way for several points and at various wave lengths, it at once becomes a standard of comparison of resistance for any other inductances within its limits, by a method similar to the above. If the values of the resistances in Table II for any given wave length be plotted, it will be found that the results do not fall on a straight line, that is, the high frequency resistance increases more rapidly than in proportion to the number of turns of the coil. This result is not in accordance, I believe, with any of the various formulae which have been given for the high frequency resistance of inductances. The curvature appears, however, only in the first part of the curve. This is probably due to the distribution of the magnetic field.

MINERALOGY.—*The calculation of mineral formulas.* WALDEMAR T. SCHALLER, Geological Survey.

In the calculation of the ratios of a mineral analysis, it is customary to select arbitrarily one of the constituents as unity, or as some rational multiple of unity, and on this basis to calculate the ratios of the other constituents. As an example I will give the analysis of pearceite from the Veta Rica Mine, Sierra Mojada, Coahuila, Mexico, as recently published[1] by Frank R. Van Horn and C. W. Cook.

| | ANALYSIS | RATIOS | | |
|---|---|---|---|---|
| S | 17.46 | 0.5444 | 10.80 | 11 |
| As | 7.56 | 0.1008 | 2.00 | 2 |
| Ag | 59.22 | 0.2744* | 7.886 | 8 |
| Cu | 15.65 | 0.1231* | | |
| Sb | 0.00 | | | |
| | 99.89 | | | |

* Considered as $(Ag_2)$ and $(Cu_2)$ respectively.

[1] Amer. Journ. Sci. (4), vol. 31, p. 518, 1911.

The ratios are sufficiently close to 11 : 2 : 8 to show that these are the correct numbers. In reality the ratios are very much closer to 11 : 2 : 8 than the figures given by Van Horn and Cook suggest, as will be shown below.

The first column from the ratios given above is reproduced below (1) with the molecular proportions for silver and copper combined, and all the quantities multiplied by 100 for convenience of calculation. When the lowest number is taken as unity it is readily seen that the ratios are approximatly $5\frac{1}{2} : 1 : 4$. If the first figure be divided by 2 times $5\frac{1}{2}$ (these numbers are doubled to avoid fractions), the second by $2 \times 1$, and the third by $2 \times 4$, the figures under (2) are obtained. These numbers should be nearly the same. Their average is 4.986. If now the ratios obtained from the analysis be divided by this average value, namely 4.986, the figures given under (3) are obtained which are considerably closer to 11, 2, and 8 respectively, than the ones given by Van Horn and Cook.

| | (1) | | (2) | (3) |
|---|---|---|---|---|
| S | $54.44 \div (2 \times 5\frac{1}{2})$ | = | 4.949 | 10.92 |
| As | $10.08 \div (2 \times 1)$ | = | 5.040 | 2.02 |
| $Ag_2,Cu_2$ | $39.75 \div (2 \times 4)$ | = | 4.969 | 7.97 |
| | Av. | = | 4.986 | |

Ratios such as those given above under (3) are still too far from the whole numbers they approximate for comparison as they stand. The figures should be reduced to multiples of approximate unity which can then be directly compared, as follows:

| | | | | | |
|---|---|---|---|---|---|
| S | 10.92 | = | $11 \times 0.99(3)$ | = | $11 \times 0.99$ |
| As | 2.02 | = | $2 \times 1.01$ | = | $2 \times 1.01$ |
| $Ag_2,Cu_2$ | 7.97 | = | $8 \times 0.99\ (6)$ | = | $8 \times 1.00$ |

These figures show that the ratios deducible from the pearceite analysis are in fact far closer to the whole numbers 11 : 2 : 8 than the ratios 10.80 : 2.00 : 7.886 given by Van Horn and Cook, which were obtained by arbitrarily selecting one of the numbers as unity. The form in which the last set of ratios is given above appears to express most accurately the relations derivable from the analysis.

BOTANY.—*Chaetospermum, a new genus of hard-shelled citrous fruits.* WALTER T. SWINGLE, Bureau of Plant Industry.

The wild relatives of the common orange may be divided into several rather distinct groups. One of these consists of the hard-shelled citrous fruits of which the best known representatives are the bael fruit, *Belou marmelos* (L.) W. F. Wight (*Aegle marmelos* (L.) Corrêa), and the wood apple of India (*Feronia elephantum*, Corrêa). These two were known to Rheede, Rumphius, Hermann and other pre-Linnean botanists as well as to Linnaeus himself.

A number of other plants belonging to this group are known to botanists. Four of them are natives of Africa and have come to light only recently. In the East Indies two species have long been known, but are little understood as yet. One of these, *Feronia lucida* Scheffer, grows in Java and is closely related to the wood apple of India. The other, the subject of the present note, was described in 1837 by Blanco, in the first edition of his *Flora de Filipinas*, under the name *Limonia glutinosa.* He saw it growing on Mt. Arayat, Province of Manila, Luzon Island, and noted that it was called *malacabuyao* or *tabog* by the Tagals.

In the second edition of his *Flora de Filipinas*, published in 1845, Blanco recognized that this plant was related to the wood apple and renamed it *Feronia ternata.*

About 1878, Andrés Naves, in editing a new illustrated edition de luxe of Blanco's *Flora de Filipinas*, recognized that the tabog was more nearly allied to the bael fruit than to the wood apple and accordingly transferred it to the genus Aegle making a new specific name *A. decandra.* In 1904 Merrill restored Blanco's original specific name, *Aegle glutinosa* (Bl.) Merrill.

An examination of the typical material in the Botanical Museum at Dahlem bei Berlin, made by the writer in June, 1911, showed *Limonia Engleriana*, Perkins, to be the tabog, as had been noted by E. D. Merrill on one of the paratypes.

In establishing a new genus, *Aeglopsis*,[1] from tropical West

[1] Swingle, Walter T., 1912, Le genre *Balsamocitrus* et un nouveau genre voisin, *Æglopsis*, in Bull. Soc. bot. de France (1911), 58 (mém. 8d): 225–245, figs. A, B, pls. 1–5 (March 2) also in Chevalier, Aug., Novitates florae africanae, fasc. 4, p. 225–245.

Africa, belonging to the hard-shelled citrous fruits, it became necessary to look up all the known plants of this group. This resulted in bringing to light a new species of wood apple from Indo-China, the type of a new genus[2] closely related to *Feronia*.

A reëxamination of the tabog, undertaken at the same time was facilitated by a fruiting specimen in the National Herbarium collected by E. D. Merrill (No. 3641, Concepción, Prov. Tárlac, Luzon, November, 1903), and showed that this species differs from *Belou marmelos* in flower, fruit, leaf and germination characters so profoundly that it must be put in another genus. The stamens of the tabog are ten in number, being twice as many as the petals instead of very numerous (more than four times as many as the petals) as in the bael fruit. The ovary of the tabog has 8 to 10 cells instead of 10 to 15 commonly found in the bael fruit. The fruit is oblong or long oval with low longitudinal ridges corresponding in number and position to the segments, and has a thick leathery rind. The bael fruit is spherical or pyriform, never ridged, and has a very hard, woody rind.

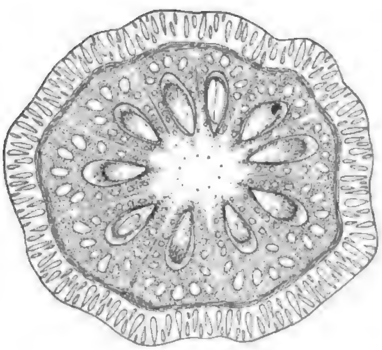

Fig. 1. Cross section of a fruit of *Chaetospermum glutinosa* (Concepción, Luzon, November, 1903, E. D. Merrill, No. 3641). Natural size. Shows the thick rind with long slender pointed oil glands; a thin intermediate layer; and an endocarp composed of spongy vesicular tissue (thickened ovary walls) surrounding the cells. The pith is not vesicular.

The cells of the tabog fruit are lined with a spongy tissue showing very large cavities or vacuoles. Nothing of the sort is found in any other of the hard-shelled citrous fruits (see fig. 1).

The leaves of the tabog are persistent instead of deciduous as in the bael fruit and have smaller, more rounded lateral leaflets. On germination the cotyledons become aerial in the tabog but remain hypogeous in the bael fruit.

Already in 1846 Roemer in his Synopses monographicae made a subgenus, *Chaetospermum*, under the genus *Limonia*, for this

[2] This will appear shortly in the Bulletin de la Société botanique de France

species, stating that he believed this to be the type of a new genus "-Typum novi generis certe format, ex ordine forsan excludendi."[3]

In view of Roemer's conviction that the plant constitutes a new genus it seems fitting to raise his subgenus to generic rank.

**Chaetospermum** (Roem.) n. gen.

*Chaetospermum* Roemer, M. J., 1846, Synop. Monogr. **1**: 39, as subgenus of *Limonia.*

Type species *Limonia glutinosa,* Blanco, M., 1837, *Flora de Filipinas,* p. 358.

A genus related to Belou, from which it differs in having persistent leaves with small rounded sessile lateral leaflets, fewer stamens (twice as many as the petals), fewer ovarial cells (8 to 10), an oblong ribbed fruit with a thick leathery rind and cells lined with a spongy tissue containing many large cavities or vacuoles (see fig. 1).

*Leaves* persistent, trifoliate, lateral leaflets small, sessile, usually less than one-third as long as the median, more or less blunt at the base or even rounded. Terminal leaflet gradually narrowed at the base. *Petioles* narrowly winged with a joint at the point of attachment of the leaflets. *Spines* slender, straight, sharp, in pairs at the axils or else one of the spines is replaced by a branch. *Inflorescences* axillary, composed of from one to several flowers on rather long, slender pedicels. *Flowers* perfect, 5-merous; calyx 5-lobed, petals 5, stamens 10, free. *Pistil* with a well developed style and a thick rounded stigma. *Ovary* with 8 to 10 cells, each containing numerous ovules. *Fruit,* oblong, longitudinally ribbed, with a very thick leathery rind, and with cells (filled with gum?) surrounded with watery tissue containing large cavities or vacuoles. *Seeds* numerous in the long narrow cells, flattened ovate, hairy. *Germination*—Cotyledons aerial, not increasing in size; first foliage leaves opposite, broadly ovate, subseriate, sessile, abruptly narrowed at base.

A small tree native to the Island of Luzon, Philippine Archipelago.

Chaetospermum resembles Belou in having trifoliate leaves, a many-celled ovary, and hairy seeds, but differs in many essential characters as noted above.

It agrees with Feronia in having aerial cotyledons which do not, however, show any increase in size during germination as in this latter genus. It agrees with Aeglopsis in having fruits with a leathery rather than a woody cortex, altho there are woody elements in the rind of an Aeglopsis fruit which seem to be lacking in Chaetospermum.

[3] Roemer, M. J., 1846, Syn. monogr. Fasc. **1**: 39.

Chaetospermum differs widely from all the other hard-shelled citrous fruits and constitutes a striking new genus. It undoubtedly belongs to the hard-shelled group of citrous fruits tho it alone does not (so far as known) have woody elements in the cortex.

Only one species is known; its synonomy is as follows:

**Chaetospermum glutinosa** (Blanco) n. comb.

*Limonia Glutinosa* Blanco, 1837, Fl. Filip. Ed. I, p. 358.

*Feronia ternata* Blanco, 1845, Fl. Filip. Ed. II, p. 252.

*Ægle decandra*, Naves, 1878 (?), in Blanco, Fl. Filip. Ed. III, pl. 124.

*Aegle glutinosa* (Blanco), Merrill, 1904, in Phillip. Gov. Lab. Bur. Bull. n. 6, p. 12.

*Limonia Engleriana*, Perkins, 1905, Frag. Fl. Phillipp. Fasc. III, p. 163.

*Belou glutinosa* (Blanco) Skeels, 1909, Bull. 162 Bur. Pl. Ind. Dept. Agr. p. 26.

Illustrations:

Naves 1878 (?) in Blanco, M., Flora de Filipinas, Ed. 3. vol. 2, pl. 124 (Lvs. fls. and fts.)

Vidal y Soler, S., 1883, Sinopsis de familias y generos de plantas leñosas de Filipinas, pl. 25, fig. J, 1–5 (Fls. fts. and seed).

Swingle, Walter T., 1912, Le genre Balsamocitrus, etc., l. c., pl. 5 (Young plant).

The tabog is a small tree native to the central part of Luzon, Philippine Islands. This species has been reported from the provinces of Tárlac, Pampanga (the type locality is Monte Aráyat in this province), Bataán, Manila, and Mórong. I have seen specimens from all of these provinces except Pampanga and Mórong, and have also seen a specimen in Herb. Kew collected by Vidal y Soler in 1886 at Angat, Prov. Bulacán. Young plants from one to three years old are now growing in the greenhouses of the Bureau of Plant Industry.

It has been found that oranges, lemons, grape-fruits, kumquats and other citrous fruits grow well when budded or grafted on such young tabog plants.

BOTANY.—*Chelonocarpus, a new section of the genus Annona, with descriptions of* Annona scleroderma *and* Annona testudinea. W. E. Safford, Bureau of Plant Industry.

While on a mission for the United States Department of Agriculture, in April, 1902, Mr. Guy N. Collins of the Bureau of Plant Industry found at the railway station of Morales, not far from Puerto Barrios, Guatemala, a hard-shelled, globose custard-apple quite distinct from all Annona fruits hitherto known. He photographed two of the fruits, but was not able to secure flowers or leaves of the trees producing them. In February of the following year specimens of the same fruit together with herbarium specimens of the leaves were collected by Mr. Percy Wilson of the New York Botanical Garden near Puerto Sierra, Honduras, where the species occurred as a forest tree locally known as "Anona del monte," or wild Annona. One year later, in April, 1904, Mr. O. F. Cook collected fruits of a hard-shelled Annona very similar to the above species but oblate in form, broadly umbilicated and with the shell less regularly divided into polygonal areoles. At the same time Mr. Cook secured herbarium specimens including both leaves and flowers, the former differing somewhat in size and shape from those of the Honduras tree, tho of the same character, and the latter resembling the flowers of the section Atta, in shape, but with the receptacle and consolidated gynoecium so distinct as to further set apart the Guatemala species and its allies as a distinct group or section of the genus Annona. For this section I propose the name Chelonocarpus, suggested by the hard tortoiseshell-like surface of the fruit. On account of the complete nature of the material collected by Mr. Cook the species collected by him is made the type of the section.

## Section Chelonocarpus

### Hard-shell Custard-apple Group

Flowers in shape resembling those of the section Atta; peduncles clustered, usually issuing from the bark of old branches or stems (caulifloral); calyx gamosepalous, 3-lobed; receptacle (tor-

us) hemispherical or conoid, not clothed with hairs or bristles but with minute scale-like processes subtending the bases of the filaments in more or less vertical rows; corolla 3-petaled, the petals valvate, oblong or linear-oblong, the upper part triquetrous or keeled within, the lower part concave and swollen so as to include the essential parts; stamens with stout filaments bearing upon their back a pair of linear pollen sacs and terminating in an expanded minutely verrucose connective above them; carpels cohering firmly to form a solid gynoecium, with the outer ovaries minutely hirsute and the styles sharply articulated at the base and falling off soon after pollination has been effected; fruit (syncarpium) spheroid or conoid, composed of firmly consolidated one-seeded carpels inclosed in a thick rigid shell with the surface divided into rhomoboid or polygonal areoles by raised ridges; seeds smooth and glossy, oblong, somewhat compressed but not marginate, brown, or grayish brown to mouse-colored, surrounded by juicy pulp; leaves coriaceous, oblong, acuminate, with the midrib impressed above and raised beneath and the lateral nerves anastomosing before reaching the margin and connected by inconspicuous reticulating veins.

The species belonging to this section have been confused with the common custard-apple or bullock's heart (*A. reticulata* L.) and the chirimoya (*A. cherimola* Miller) from both of which they are easily distinguished by the large glossy seeds and the smooth, flat, coriaceous oblong leaves, as well as by the coherent nature of the gynoecium and the thickness of the rigid shell of the fruit. The two species here described may be broadly distinguished as follows:

Fruit oblate-spheroid in form, umbilicate; leaves not exceeding 9 inches (23 cm.) in length, abruptly acuminate. . . . . . . . . . . . . . . . . . . . . . . *Annona scleroderma*

Fruit globose in form, not umbilicate; leaves sometimes 1 foot (30 cm.) long, gradually acuminate *Annona testudinea*

In addition to these species it is probable that *A. Pittieri* Donnell Smith, from southern Costa Rica, should be assigned to this section, as the character of its leaves and flowers would in-

dicate. Its fruit is described as conoid and its leaves do not exceed 18 cm. in length.[1]

**Annona scleroderma** sp. nov. Hard-shell Custard-apple. Box-té of Guatemala.

A vigorous tree. Young growth minutely ferrugineous-pubescent. Leaf-blades oblong, abruptly acuminate, rounded at the base, 14 to 20 cm. long, 5.5 to 6 cm. broad, coriaceous, glabrous when mature, when young minutely ferrugineous-pubescent beneath, dark-green above, becoming olive-green when dry, midrib impressed above and raised beneath, lateral nerves not conspicuous, the parenchyma between them finely reticulate and punctate; petiole 14 to 18 mm. long grooved above in continuation of the median channel, when young minutely ferrugineous-pubescent, at length glabrate. Peduncles extra-axillary, usually in clusters of 3 or more issuing from the bark of old branches (cauliforal) with a small ovate bracteole below the middle and one at the base, appressed ferrugineous-pubescent like the young growth, about equal to the petioles in length. Flowers cinnamon-brown, appressed puberulent, calyx gamosepalous, 3-lobed, 6 to 6.5 mm. in diameter, minutely ferrugineous-pubescent on the outer surface; petals 3, valvate, closely cohering in the bud, the upper part linear or linear-oblong and triquetrous, the base swollen and concave closely covering the essential parts of the flower; inner petals wanting (in all specimens examined); receptacle conoid or hemispherical, not clothed with hairs or bristles between stamens as in many other species but with minute scale-like protuberences subtending the bases of the filaments, disposed in distinct almost vertical rows; gynoecium about 4 mm. in diameter, composed of firmly cohering carpels 2.3 mm. long with the outer ovaries clothed with appressed glossy rufous or chestnut-colored hairs; styles ovate to oblong, sharply articulated at the base, turning black and soon falling off after pollination has been effected; stamens 1.7 to 1.8 mm. long, with the stout filament light-yellow mottled with orange-red, and the swollen connective above the pollen sacs minutely verrucose, as seen under the microscope. Fruit depressed-globose, or oblate, broadly umbilicate, the surface of the thick rigid shell divided into angular areoles corresponding to the individual closely-cohering carpels by raised obtuse ridges; seeds oblong to oblong-obovate, somewhat compressed but not marginate, about 2 cm. long and 1 cm. broad, with the testa smooth and glossy, at length chocolate brown, endosperm ruminate, with the minute embryo embedded in its base; pulp juicy, not adhering to the seeds, pleasantly aromatic, with mango-like flavor, edible.

Type in the U. S. National Herbarium, No. 850041, collected at Cahabon, state of Alta Verapaz, Guatemala, April 20, 1904, by O. F. Cook (No. 89). Distribution: Mountains of Alta Verapaz, Guatemala, across the boundary into Mexico and as far north as Oaxaca.

[1] *A. Pittieri*, Donn. Sm., Bot. Gaz. **24**: 389. 1897.

EXPLANATION OF FIGURE 1. A cluster of unopened flowers, leaves, fruit, and seeds of *Annona scleroderma* natural size; and the torus marked with vertical rows of stamen-scars and bearing the cohering mass of carpels (gynoecium), enlarged 3 diameters. Drawn by Mr. J. M. Shull.

In addition to the type material, seeds sent in 1910 by Prof. Felix Foex to the U. S. Department of Agriculture from the state of Oaxaca belong very probably to this species (Seed collection No. 29316). In a note accompanying them Prof. Foex writes as follows: "These seeds came from a very interesting fruit of good size, good shape, pretty appearance, and having large seeds: the skin is thick as the shell of a coconut but not so hard; it resists well a pretty hard shock and pressure, and would be very good for packing and shipping."

Mr. O. F. Cook in his field-notes made the following entry: "The fruit called by the Kekchi Indians of Alta Verapaz box-té, or bosh-té, is curious rather than beautiful. The shell is divided into angular depressed areoles by raised ridges. When mature the ridges are dark brown and the areoles between them green. The pulp is readily separable into slender pyramids. These are normally 1-seeded, but in many cases they are seedless. The texture of the pulp is perfect, the flavor aromatic and delicious with no unpleasant aftertaste. It is much richer than the soursop, with a suggestion of the flavor of the zapote blanco, or matasano (*Casimiroa edulis*), but not in the least objectionable. It can be eaten most conveniently with a spoon. The most fragrant pulp is close to the rind. The seeds separate from the surrounding pulp more readily than in most annona fruits."

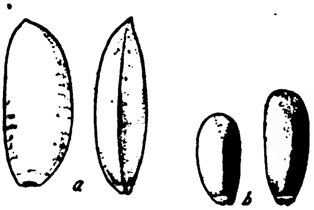


Fig. 3. Seeds of *Annona testudinea*, *a*, compared with seeds of *A. reticulata*, *b*, with which the present species has hitherto been confused.

**Annona testudinea** sp. nov. Tortoiseshell Custard-apple. Anona del Monte of Honduras.

A forest tree 12 to 15 meters high. Leaf-blades oblong or oblong-elliptical, acuminate at the apex, abruptly cuneate or rounded at the base and usually decurrent on the petiole, those near the base of branch sometimes retuse or rounded at the apex, as in the case of many other species of Annonaceae, 25 to 35 cm. long and 7.5 to 9 cm. broad, coriaceous, smooth and flat with the midrib impressed above and very prominent beneath; lateral nerves not prominent, connected by inconspicuous anastomosing veins; petiole rather long (22 to 25 mm.), at length glabrous, grooved above. Flowers not observed. Fruit globose, hard-shelled, 8 to 9 cm, in diameter, its surface divided into polygonal areoles by raised ridges, suggesting tortoiseshell in its general appearance. Seeds 20 to 22 mm. long and 10 to 12 mm. broad, sometimes elliptical in cross-section or slightly compressed with one or both edges sharp-cornered but not marginate, testa smooth and glossy, light-brown or

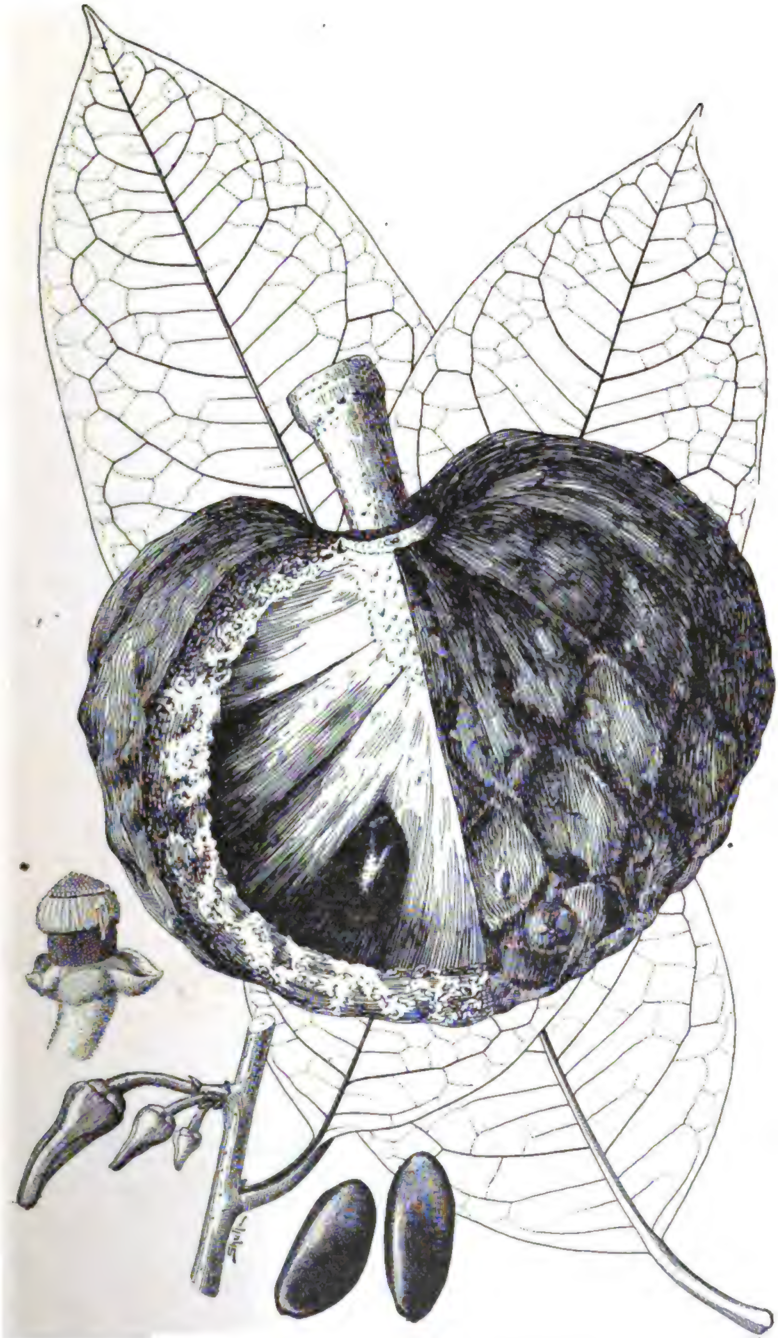

Fig. 1. ANNONA SCLERODERMA SAFFORD.

mouse-colored, faintly revealing the transverse wrinkels of the ruminate endosperm; pulp very juicy, aromatic, edible.

Type in the Herbarium of John Donnell Smith, collected in the forest near Puerto Sierra, Honduras, February 7, 1903, by Percy Wilson (No. 351). Specimens examined: Material from the type collection in the Herbarium of the New York Botanical Garden and the Donnell Smith Herbarium, Baltimore, Maryland; also photographs of fruits purchased at Morales, Guatemala, not far from Puerto Barrios, April 6, 1902, by Mr. Guy N. Collins (No. 3833).

EXPLANATION OF FIGURE 2. *Annona testudinea*, from type material, natural size, showing a typical acuminate leaf and a basal leaf with retuse apex. Drawn by Mr. Ivan M. Fitzwater.

The fruit, as described by Mr. Collins in his field notes, "has a shell about one-eighth of an inch thick, which breaks with almost a fracture, with a fleshy core [receptacle] reaching from the base nearly to the center of the fruit. The pulp of the ripe fruit is rich, soft, and watery, with only a faint suggestion of the sandiness noted in the Annona observed at Sepacuité [*A. reticulata* L.], very aromatic and with a slight pine-like flavor, turning brown when perfectly ripe and not adhering to the seeds. The color of the outer surface is grayish or bluish green, somewhat pruinose, becoming purplish at maturity." According to Mr. Percy Wilson, the fresh leaves are dark green above and paler beneath. The tree, known locally as "anona del monte," or wild custard-apple, is highly esteemed by the natives for its fruit. The latter is green-ridged with brown seeds having the odor of turpentine when cut, and with good edible pulp, which is easily separable.

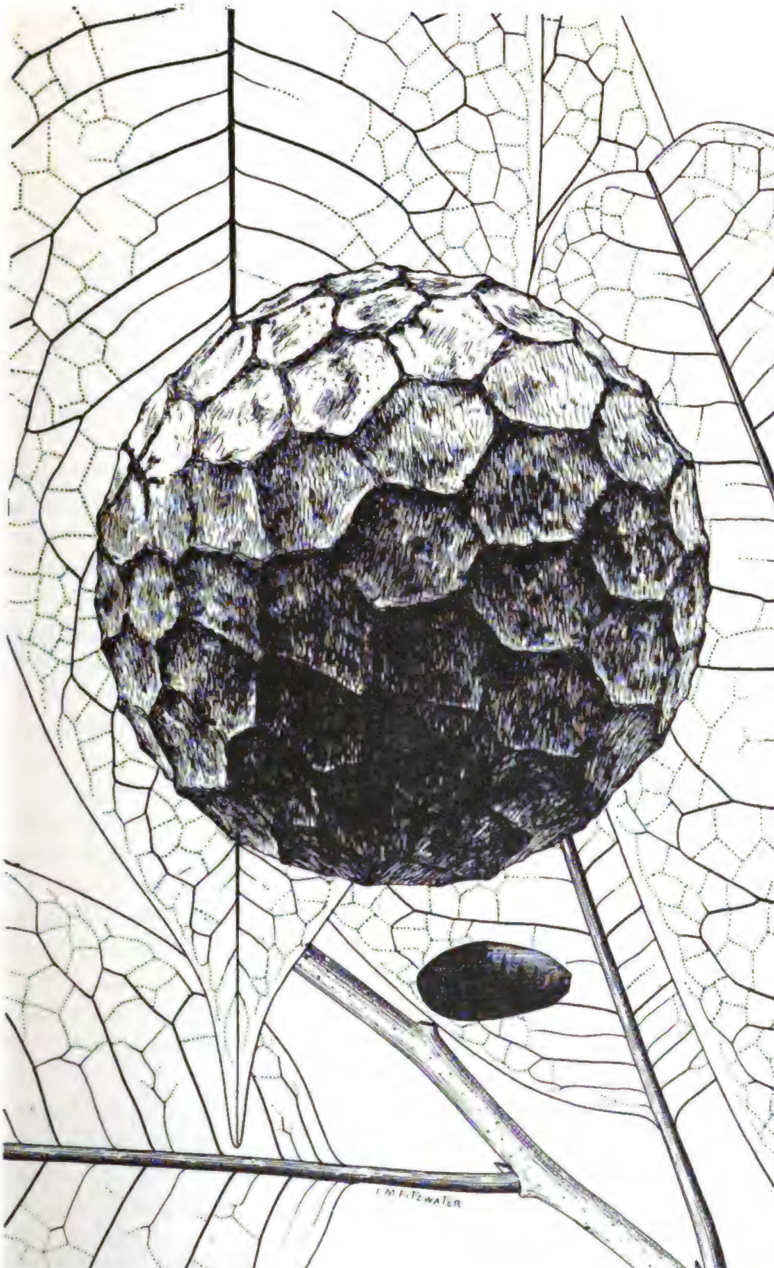

Fig. 2. ANNONA TESTUDINEA SAFFORD.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

ASTROPHYSICS.—*Report on the astrophysical Observatory, Smithsonian Institution, for year ending June 30, 1912.* C. G. ABBOT.

The year has been notable for expeditions to Algeria and California to test the supposed variability of the sun by making simultaneously at these two widely separated stations spectrobolometric determinations of the solar constant of radiation. The measurements in Algeria agree with earlier ones at Washington and Mount Whitney and indicate that Mount Wilson values are systematically a little low. Apart from this systematic error the average accidental differences between Algerian and Mount Wilson determinations were only 1.2 per cent, indicating an average accidental error of a single solar constant determination at one station of only 0.9 per cent. So far as yet reduced, high solar constant values obtained in Algeria coincide with high values at Mount Wilson and vice versa. A solar variation of 4 per cent was indicated at both stations in the first half of September, 1911. Many values remain to be computed, but it can now hardly be doubted that the outcome will prove conclusively the irregular short-period variability of the sun.

Numerous copies of the silver disk pyrheliometer have been standardized and sent out, mainly to foreign governmental meteorological services.

Valuable results have been secured in the research on the transmission of radiation through atmospheric water vapor. An accurate method of estimating the total water vapor contents of the atmosphere between the observer and the sun has been devised by Mr. Fowle. C. G. A.

METEOROLOGY.—*Atmospheric studies.* J. W. SANSTROM. Bulletin of the Mount Weather Observatory, **5**: 3–51. 1912.

The first part of this paper is devoted to a number of fundamental or general principles in meteorology, all of which are minutely and clearly

explained. The second part treats of the vortex movements of the atmosphere, and is by no means such easy reading as the first part.

The author made the observations upon which his article is based during the winter and in the mountains of Sweden, and hence under exceptionally favorable opportunities for the study of air movements. A comparatively warm ocean was on one side of him and a cold continental area on the other, so that he himself was on the inside, as it were, of a gigantic heat engine where he could see and experience all that was taking place.

Among other things, an account is given of the movements of the wind as it blows across regions covered by fine loose snow. In this case the lower air, to the depth of 20 to 50 meters, becomes filled with the snow in the same manner that it becomes filled with dust when blowing over a desert. Now the snow obviously increases the density of the stratum of air it is in, and hence this particular stratum moves up the windward side of a mountain or other slope comparatively slowly and then, as soon as it has passed the crest, flows down the leeward side with great violence. In one observed case, this rapidly falling loaded air set up great surging billows in the atmosphere at the foot of the mountain that lasted for hours, with only 10 to 15 minute intervals between perfect calm and hurricane violence, and that were felt to a distance of 140 kilometers from their place of origin.

The second part of the paper begins with a general account of vortex motion which the author makes clear by the aid of drawings and numerical calculations applicable to simple cases. The principles thus established are then applied to the vortices of the atmosphere of which there are two distinct types: Those which are roughly circular and symmetrical, with their vortex filaments nearly vertical, and those which are very unsymmetrical with horizontal filaments. The first obviously applies to whirl-winds, tornadoes and the like, and is relatively simple, while the second concerns approximately horizontal circulation with an upper and a lower current flowing in opposite directions. This is called a "gliding" vortex and the plane separating the oppositely directed currents a "glide" plane. It is further explained that in general the "glide" plane is more or less inclined, and suitable equations are developed for the computation of the rate at which energy is being transformed in such a vortex.

A remarkable example of the "gliding" vortex commonly occurs during the winter along the coast of Norway. Here a cold east wind flows down the mountains and onto the ocean with great violence, while

at an elevation of about 1 kilometer a relatively light and warm counter current flows to the east. In reality this is a "land breeze" on a very large scale, so large indeed that per kilometer of coast-line heat energy is converted into wind energy frequently at the rate of 45 million horse power! W. J. Humphreys.

TERRESTRIAL MAGNETISM.—*A new type of compass declinometer.* R. L. Faris. Journal of Terrestrial Magnetism and Atmospheric Electricity **17**: 109–114. 1912.

This paper describes a new form of instrument for ascertaining the magnetic declination at stations where the true bearing to some other point is already known, and is especially adapted for use of general survey parties when working in remote regions, such as Alaska or the Philippines, where it is possible at nominal cost to ascertain the magnetic declination much in advance of the possibility of a general magnetic survey.

Experience in the Coast and Geodetic Survey and elsewhere has shown that acceptable magnetic declination results can be obtained with pivot suspension needles. The instrument is described as follows:

It is essentially a compass needle enclosed in a rectangular needle box with peep sights, which is rigidly mounted on a graduated horizontal circle. The needle lifter and some of the other details are novel and have been worked out with great care. The base rests on three leveling screws and has double centers of brass. The horizontal circle, which is 152.4 mm. in diameter, is read by two verniers to single minutes of arc. The needle is mounted in a rectangular box the inside dimensions of which are 164 mm. long, 31.5 mm. wide, and 17 mm. deep. This box is secured to the cover plate of the horizontal circle. At each end of the box is a graduated arc (arc graduated to 10 minutes), about 10° in extent on each side of the zero in the middle. Vertical peep sights, 40 mm. high, are attached to the ends of the box so that the zeros of the graduations, the needle pivot and the peep slits are in the same vertical plane. The top edge of the needle is straight, its ends and the apex of the agate cup suspension being in a straight line. The needle lifter is of special design and direct acting, and so arranged that the instrument cannot be packed in its packing case without first lifting the needle off its suspension pivot. When the needle is raised off the pivot it is held firmly in place between the lifter and a flat brass spring in the top of the needle box. The needle and horizontal circle readings are made with the aid of three reading microscopes. The instrument is leveled by means of an adjustable circular level mounted on the cover plate of the horizontal circle. The needle is 148.5 mm. long and is made of "magnet steel;" the dimensions of its cross-section are 0.6 mm. by 3.5 mm. The width of the peep-sight slits is 0.5 mm.

Upon testing this instrument under actual field conditions it was found that the needle, on account of its rather unusual length, required too frequent readjustment of balance. As a remedy for this inconvenience the point of suspension (agate cup) has now been raised, likewise the ends of the needle have been bent upward to bring them again in line with the suspension point. R. L. F.

PHYSICS.—*On the density of solid substances, with especial reference to permanent changes produced by high pressures.* John Johnston and L. H. Adams. Journal of American Chemical Society, **34**: 563–584. 1912.

With a new and improved form of pyknometer the density of salts and other substances has been determined with an accuracy of 3 or 4 units in the fourth decimal place, that is, within 0.02 per cent. In many cases, however, such accuracy is unnecessary, since the variations of density due to inhomogeneities of the material may be much greater than this.

Powdering a crystalline substance does not change its density by an amount which we can detect with certainty, provided that the material is homogeneous and free from cracks and holes; but if the substance is not homogeneous, then, as might be expected, the fine powder is denser than the coarse particles.

Neither does very high hydrostatic pressure produce any after-effect on the density of strictly homogeneous crystalline compounds.

But if the pressure be not uniform, then the density of a metal which has been subjected to such compression—or has been deformed in any other way—usually increases first (owing presumably to the filling up of pores and cracks) and then decreases, sometimes even so as to reach a final density less than the original value. Subsequent annealing of the specimen causes a renewed increase of density. The direction of the change of density on compressing bismuth is, contrary to Spring's conclusion, the same as that for other metals, namely a decrease of density, following upon deformation. The bearing of these results upon the question of the "flow" of metals is discussed: they are shown to be in harmony with the idea that the "flow"—or indeed any deformation—of a metal is a manifestation of a real melting produced by the unequal strains set up during the process.

Finally, it is important to emphasize the fact the density of most substances is somewhat variable, owing to a lack of complete homogeneity of the material. In consequence of this, slight changes of density

can not be regarded as good evidence for the occurrence of any transformation or chemical reaction, whether produced by subjecting the system to compression or by other means. J. J. and L. H. A.

PHYSICS.—*Mixtures of amorphous sulfur and selenium as immersion media for the determination of high refractive indices with the microscope.* H. E. MERWIN and E. S. LARSEN. American Journal of Science, **34**: 42–47. 1912.

Fused mixtures of sulfur and selenium are glassy when cold. By standardizing the mixtures with respect to their refractive indices by measurements on prisms molded into the angle between glass plates, they can be used to match the refractive indices of suitable substances immersed in them and studied under the microscope. A chart showing the refractive indices of various mixtures for several wave-lengths has been prepared, and a method of interpolating values of refractive indices, obtained by using a monochromatic illuminator, explained

H. E. M.

GEOCHEMISTRY.—*The sulfides of zinc, cadmium, and mercury; their crystalline forms and genetic conditions.* E. T. ALLEN and J. L. CRENSHAW. Microscopic study by H. E. Merwin. American Journal of Science, **34**: 341–396. 1912.

The sulfides of zinc are enantiotropic, with an inversion point at 1020°. Sphalerite is the stable form below this temperature, wurtzite above. Their indices of refraction, dispersion, and specific gravities were determined. Iron in the form of ferrous sulfide is present in solid solution in the ferruginous sphalerites, since the specific volume, index of refraction, and inversion-point change continuously with increasing percentage of iron. Sphalerite was formed synthetically by action of alkali sulfides on zinc salts at 200° and above. Wurtzite was obtained by action of hydrogen sulfide on solutions of zinc salts containing free acid at temperatures between 250° and 350°.

Only one crystalline form of cadmium sulfide was obtained. It is identical with the mineral greenockite. Crystallographic and optical measurements and determinations of specific gravity were made on a very pure synthetic preparation.

Besides cinnabar, a black sulfide of mercury, probably identical with metacinnabar, and a new form, hexagonal, but with properties distinct from cinnabar, were obtained. Cinnabar is the stable form; the other two are monotropic forms.

The most interesting result for geochemistry which was obtained in these synthetic studies was the following: The unstable crystalline forms, metacinnabar, wurtzite, and marcasite, are obtained only from acid solutions, while the corresponding stable forms, cinnabar, sphalerite, and pyrite, are the only product of alkaline solutions, tho they may be obtained from acid solutions also. E. T. A and J. L. C.

PETROGRAPHY.—*Microscopical petrography from the quantitative viewpoint.* FRED. EUGENE WRIGHT. Journal of Geology, **20**: 481–501. 1912.

In this paper attention is directed to the importance of good quantitative work in microscopical petrography which has now passed the qualitative, reconnaissance stage of its development and is entering upon large problems, essentially quantitative in nature, which require precise data of observation for their solution. The different optical properties used in the determination of minerals are classified in detail and simple effective methods are briefly described which experience has shown to be well adapted for the determination of the different optical constants of mineral plates and grains. F. E. W.

PETROGRAPHY.—*Petrographic study of the specimens of loess, tierra cocida, and scoria collected by the Hrdlicka-Willis Expedition.* FRED. EUGENE WRIGHT and CLARENCE N. FENNER. Included in the volume, Early man in South America, by Ales Hrdlicka in collaboration with W. H. Holmes, Bailey Willis, Fred. Eugene Wright, and Clarence N. Fenner. Bulletin, Bureau of American Ethnology, Smithsonian Institution, **52**: 55–98. 1912.

This collection was found to contain several extraordinary rock types, and for the solution of the problems which they present, three distinct lines of attack were followed: (1) the usual detailed petrographic-microscopic examination of the rocks; (2) chemical study of the different rock types; (3) thermal study of the specimens at different temperatures and comparisons of the products thus obtained with the natural products.

The *loess* consists in large measure of volcanic and eruptive material. Salic volcanic glass is present in practically every specimen and may become so abundant that it constitutes 90 per cent of the whole. The minerals are remarkably fresh and unaltered, while the amount of argillaceous material present is relatively small in most of the specimens. These facts may be considered indicative of tremendous and

widespread volcanic activity of the explosive type during or just preceding the formation of the loess.

The specimens of *tierra cocida* are composed, for the most part, simply of loess fragments which have been indurated and reddened by heat action, between 850° and 1050°. The loess and tierra cocida are similar in general character and composition.

The *scoriae* are not normal volcanic scoriae. They have been produced by the melting down of an original clastic material (loess) under conditions which protected the molten mass from oxidation. The hypothesis is advanced that the loess formation was intruded by igneous masses which melted down the adjacent loess and formed the present black scoriae. The lack of oxidation of the scoriae and their abundance in the field precludes the possibility that they were formed by the melting down of loess by bonfires or any type of fire in the open air. Prehistoric man is not, therefore, responsible for their occurrence.

F. E. W and C. N. F.

PETROLOGY.—*Study of a contact metamorphic ore-deposit.' The Dolores mine, at Matehuala, S. L. P. Mexico.* J. E. Spurr, G. H. Garrey, and Clarence N. Fenner. Economic Geology, **7**: 444–484. 1912.

This is a study of an interesting problem in applied geology, toward which the laboratory contributed an exhaustive petrographic investigation of the various types of rock which had been collected in the field. The problem comprised the study and elucidation of the phenomena of an unusual type of metamorphism and ore-deposition, associated with and consequent upon the intrusion of a great mass of eruptive rock into a series of sedimentary beds. In conjunction with the field-work a collection of typical rock-specimens was sent to the laboratory. From these the field relations which had been observed were confirmed and supplementary information obtained. From the different sources of information thus made available it was possible to arrive at well-grounded conclusions regarding the geological history of events, including the sequence of mineral deposition, the nature of the circulating solutions, and the relations existing between the metallic sulfides and the gangue minerals.

C. N. F.

GEOLOGY.—*Apishapa, Colo., Folio.* George W. Stose. Folio No. 186, Geologic Atlas of the United States, U. S. Geological Survey. January, 1913. Topographic, geologic, and structure maps, and sheet of illustrations.

The Apishapa quadrangle is one-quarter of a square degree situated 20 miles southeast of Pueblo, Colorado. It was geologically surveyed by G. K. Gilbert and his assistants some years ago and was recently completed and revised by G. W. Stose. The topography of the quadrangle is typical of the semiarid Great Plains region, comprising rolling treeless plains, low mesas, and deep rocky canyons. An old dissected peneplain, drainage modifications, and other physiographic features are discussed and figured. The rocks exposed are all of Cretaceous age except the oldest rocks observed in some of the deeper canyons—the Morrison formation of possibly Jurassic age—and the surficial gravels of Tertiary and Quaternary age. Lower Cretaceous rocks are recognized and mapped for the first time in this vicinity as the Purgatoire formation. The structure of the quadrangle is a sharp dome-like uplift centering in the Rattlesnake Buttes, with a total vertical displacement of 2500 feet in the quadrangle. The hard Dakota sandstone forms the land surface over a large portion of the higher part of the dome. Numerous normal faults occur on the flanks of the uplift, and the resulting intricate displacements are brought out on the geologic structure map by deformation contours. A sharp local dome structure is regarded as probably the result of the intrusion of a laccolithic body of igneous rock emanating from the source of the Spanish Peak intrusion 25 miles to the southwest. These igneous rock are represented in the quadrangle by scattered dikes of rather unusual composition. The petrographic description of these is contributed by Whitman Cross.

G. W. S.

GEOLOGY.—*Geology of the salt and gypsum deposits of southwestern Virginia.* George W. Stose. Bulletin 530 (separate N), U. S. Geological Survey. Pp. 14–37. 1912.

The salt and gypsum deposits are in the vicinity of Saltville, Va., and occur in red and gray clays of Mississippian ("Lower Carboniferous") age adjacent to the Rome fault, a great fault thrusting Cambrian dolomite and limestone upon the Carboniferous strata. A section is given of the lower Carboniferous rocks in the syncline adjacent to the fault, comprising the Price sandstone, at the base, Maccrady ("Pulaski") formation, and the Newman limestone, and the equivalence of the

gypsiferous and saline clays to part of the Maccrady formation is discussed. The various theories that have been offered to account for the accumulation of these deposits are described. The fact that the deposits are found only close to the fault and are not known to occur in quantity in the same strata any distance away from the fault, leads the author to the conclusion that disseminated salt and gypsum in the original sediments of earthy limestone, shale, and sandstone, have been concentrated in the same strata adjacent to the fault by circulating waters thru chemical affinity. The ammonia-soda process, which is used in converting the brine of these wells into soda products is described. G. W. S.

GEOLOGY.—*Index to the stratigraphy of North America.* BAILEY WILLIS. Accompanied by *a geologic map of North America*, compiled by BAILEY WILLIS and G. W. STOSE. Professorial Paper 71, U. S. Geological Survey. 1912.

This report summarizes what are regarded as the most authoritative statements concerning the geology of the North American continent. The map, 60 by 77 inches, to which the text is an extended key, is printed in 4 sheets which are folded and encased in a separate box. Its scale is 1 : 500,000 or approximately 1 inch to 80 miles. The 42 color distinctions represent as many divisions of strata. There are distinguished 6 main divisions of the pre-Cambrian, 7 of the Paleozoic, 6 of the Mesozoic, and 7 of the Tertiary. Besides these main divisions larger equivalents in parts of the continent, where details are not known or are too minute to be mapped, are represented by distinct color effect. The color scheme is planned so that the map fulfills two purposes—that of a wall map and of a pocket map. Viewed on a wall only the larger units and the different geologic provinces stand out. The Canadian shield of pre-Cambrian rocks for example is set off sharply from the parallel bands of Paleozoic rocks of the Appalachians, and the lava fields of the western states from the Mesozoic and Tertiary rocks of the Great Plains and the older rocks of the Rocky Mountains. At close range, on the other hand, the more minute subdivisions can readily be distinguished.

To facilitate references in the text, the map is divided into rectangular spaces, each embracing 4 degrees of latitude and 6 degrees of longitude, which are designated by letters and numbers. The text is closely linked to the map by these coördinates, which form the basis of the arrangement of the quotations. Except the explanatory matter in the chapters on introduction and bibliography the descriptions are arranged

in 16 chapters, each treating of one of the major geologic divisions shown on the map. Under each chapter the statements are arranged geographically according to the coördinates, in alphabetic and numerical sequence. Accordingly the geology of any locality where more than one geologic system is represented is distributed thru the various chapters in which those systems are discussed.

The compiler has depended in most cases on the papers quoted to furnish other references to earlier literature. Nevertheless, there are references in the text to 953 separate papers. Each chapter is accompanied by a small sketch map showing the areal distribution of the rocks described in that chapter as represented on the geologic map.

G. W. S.

BOTANY.—*The phylogeny of grasses.* William H. Lamb, Forest Service. The Plant World, **15**: No. 11. November, 1912.

This is a discussion of the origin of grasses, the essential differences between the tribes of grasses, and their probable derivation from a common ancestral type.

The grasses have come from lily-like plants by a reduction in the number of the parts of the flower. Among grasses the direction of evolution has been toward a reduction in the number of flowers in the spikelet. Forms with relatively more flowers in the spikelet are to be regarded as primitive, and forms that have but one flower in the spikelet have developed furtherest from the ancestral type.

The first grasses were a primitive group, probably very similar to the bamboos as we know them today, and these are the progenitors, directly and indirectly, of all the other tribes. The Bambuseae have given rise to the other tribes by three great lines of development; the Festucean Line, the Phalaridean Line, and the Andropogonean Line.

A diagrammatic drawing has been made of the spikelet, the inflorescence, and the flower of one genus to typify each tribe, and a chart has been arranged which shows the relationship of the tribes of grasses, and the structural modifications which have segregated each distinct group.

W. H. L.

PLANT PHYSIOLOGY.—*The wilting coefficient for plants in alkali soils.* Thomas H. Kearney. Bureau of Plant Industry, Circular 109, pp. 17–25. 1913.

The object of this investigation was to ascertain whether the presence of an excess of soluble salts in the soil affects the ability of plants to reduce the moisture content to the limit at which plants wilt and are un-

able to regain their turgor unless additional water is supplied (See Bulletin 230, Bureau of Plant Industry, 1912, "The Wilting Coefficient for Different Plants and Its Indirect Determination," by L. J. Briggs and H. L. Shantz). For this purpose wheat seedlings were grown in a series of soils having a graduated salt content, with sodium sulphate as the principal component.

It was demonstrated that the utilization of all "available" moisture in the soil is not prevented by the presence of "alkali" salts unless in quantity sufficient virtually to inhibit the growth of the plants. While the amount of growth made by the plants decreased regularly with the salt content of the soil, their roots, even in the mixture having the highest salt content (0.74 per cent of the dry weight of the soil) in which any growth was made, were finally able to reduce the soil moisture to the calculated wilting coefficient. Absorption was much retarded, however, in the more saline soils, the length of time required for the plants to reach the wilting point having ranged from 18 in the soil having the lowest salt content to 43 in the soil having the highest. T. H. K.

PLANT PHYSIOLOGY. *Some effects of refrigeration on sulfured and unsulfured hops.* W. W. STOCKBERGER and FRANK RABAK. Bulletin No. 271, Bureau of plant Industry, Department of Agriculture, pp. 21. 1912.

This bulletin summarizes the results of a comparative study of the effects of cold and ordinary storage on sulfured and unsulfured hops. Trade experts agreed that the samples of sulfured hops in cold storage were best in quality, but differed widely as to the undesirable effect of the treatment upon the other samples.

Determinations were made of the acidity and ester content of the volatile oils extracted from samples of the hops under each condition of storage. The conclusions drawn from these analyses are that both sulfuring and cold storage retard changes in the hops leading to an increase in acidity and ester content of the oils. Cold storage is apparently more effective than sulfuring in retarding the increase in acidity, but is less efficient than sulfuring in retarding increase in ester content. Cold storage and sulfuring combined are much more effective in retarding changes in acidity and ester content than either alone. The percentage of decrease in the content of soft resins was found to be less in the cold-stored hops than in those in ordinary storage. The evidence from the analyses goes to show that the sulfuring tends to retard changes in the content of soft resins only when combined with cold storage.

W. W. S.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE WASHINGTON ACADEMY OF SCIENCES

The 80th Meeting of the Washington Academy of Sciences was held at the Cosmos Club, Wednesday evening, December 18, 1912.

Dr. L. O. Howard gave an illustrated lecture on *The danger from imported plants and fruits, and government efforts to avoid it.* The life history of many accidentally imported injurious insects and the ravages they work were illustrated and explained. The best methods of keeping these pests in at least partial control were described. The last Congress passed a law that enables an effective quarantine to be established against insect pests of all kinds.

Dr. Howard also gave an account, which follows in full, of the celebration of the 250th anniversary of the Royal Society of London, to which he was the official delegate of the Academy.

W. J. Humphreys, *Secretary.*

*The 250th anniversary celebration of the Royal Society, London, July 15–19, 1912:* L. O. Howard, Delegate of the Washington Academy of Sciences.

To the President and Members of the Washington Academy of Sciences: I beg to submit a report on the two hundred and fiftieth anniversary celebration of the Royal Society, and in submitting this report beg to express my deep gratitude to the President and to the Board of Managers of the Academy for the appointment as delegate to this extraordinary function, which has given me one of the pleasantest experiences of a lifetime.

In talking recently with one or two members of the Academy, I have been rather surprised to find that they know little of the history of the Royal Society. One of them has even assured me that some time ago he attempted to read up on the subject, but was unable to find a competent historical sketch. Now I have no doubt that if one were to consult that much advertised but none the less reasonably competent Encyclopaedia Britannica full information on this important subject would be found. Since, however, there is undoubtedly a lack of information, it may be well to state briefly, by way of preliminary, certain facts which were brought to the writer's attention in the course of the memorable week following July 15, 1912.

The Royal Society is the oldest scientific society in Great Britain, and one of the oldest in Europe. It is usually considered as having

been founded in 1660, and King Charles II, in fact, approved of its organization in December of that year. A Charter of Incorporation, however, passed the Great Seal July 15, 1662, and it appears that King Charles gave the newly founded society a small grant at that time, which, however, and sad to relate, he was forced to withdraw before the conclusion of his reign. The first Transactions appeared March 6, 1664–65. The headquarters of the Society at the start were in Gresham College, but after the great fire of 1666 meetings were held in Arundel House, at the invitation of Henry Howard of Norfolk.

Isaac Newton was elected a fellow in 1671, and in 1703 was made President, retaining the office until his death in 1727. During his term the Society moved to Crane Court, and in 1780, under the presidency of Sir Joseph Banks, it again removed to apartments set aside in Somerset House, where it stayed until 1857, when it removed to Burlington House, Piccadilly, where it has remained ever since.

In the entire course of its history the Royal Society has been constantly consulted by the government for advice on scientific matters of national importance. Thus the Royal Observatory at Greenwich was in 1810 placed under the sole charge of the Society, and this policy has been continued down to the recent investigations of sleeping sickness and other diseases, conducted under the auspices of this organization.

The Society administers large sums for the promotion of scientific research, possessing an annual grant exceeding twenty thousand dollars for this purpose. Five medals (the Copley, two Royals, the Davey and the Hughes) are awarded every year. The Rumford and Darwin medals are awarded every two years, the latter having been awarded the present year to Dr. Francis Darwin, a son of Charles Darwin, in whose honor the medal was struck. The Silvester medal is awarded triennially, and the Buchanan medal every four years. It is worthy of note that the Buchanan medal this year was awarded to Col. William C. Gorgas, sanitary officer in charge of sanitation of the Panama Canal.

Fellows are elected strictly in accordance with their scientific attainments, except of course in the case of royalty. The admission fee is fifty dollars, and the annual dues twenty dollars, but, by the operation of a fund established in 1878, the admission fee and five dollars of the annual dues have been remitted since that time.

In making preparations for the celebration of this two hundred and fiftieth anniversary, judging by results only, since I am not informed as to the steps which were taken, considerable care was exercised in the selection of the organizations which were invited to send delegates. Apparently only the principal academies of science and the principal universities of the world were invited. At all events, less than three hundred delegates, including those from Great Britain, were in attendance, and among these the United States of America had the largest number. It may be interesting to mention the American delegates

in the order in which they appeared upon the printed diary, programme of proceedings, and list of delegates:

University of California............................Prof. H. C. Plummer
University of Chicago..................................Prof. E. B. Frost
Clark University, Worcester....................Prof. Arthur G. Webster
Columbia University, New York.......Dr. N. Murray Butler, President
Cornell University, Ithaca, N. Y..................Prof. J. H. Comstock
Harvard University...................................Prof. B. O. Peirce
Johns Hopkins University, Baltimore............Prof. W. Bullock Clark
Leland Stanford Junior University, California..Prof. Vernon L. Kellogg
University of Michigan..........................Prof. William H. Hobbs
University of Minnesota...........................Dr. Arthur Hamilton
University of Pennsylvania, Philadelphia. Dr. Edgar F. Smith, Provost
University of Princeton, New Jersey...Prof. John G. Hibben, President
University of Wisconsin..........................Prof. Charles K. Leith
Yale University..................Dr. Arthur Twining Hadley, President
American Academy of Sciences, Boston.............Prof. Edwin H. Hall
Connecticut Academy of Arts and Sciences.. Prof. W. E. Brown, F.R.S.
American Mathematical Society, New York..Prof. H. B. Fine, President
American Philosophical Society, Philadelphia
Prof. W. B. Scott, Vice-President.
Franklin Institute, Philadelphia.....................Major G. O. Squier
California Academy of Sciences, San Francisco....Mr. Joseph D. Grant
Carnegie Institution, Washington.......Dr. R. S. Woodward, President
National Academy of Sciences, Washington
Dr. Arnold Hague, Secretary
Smithsonian Institution, Washington.................Dr. Arnold Hague
Washington Academy of Sciences.....................Dr. L. O. Howard

On Monday night, July 15, 1912, exactly 250 years from the date of the passage of the Charter by the Great Seal, Burlington House, become famous during the last 65 years from the notable social and scientific functions of the Society, was brilliantly illuminated, and the delegates assembled, many of them just from their steamers and trains, for the purpose of registration and for informal meeting and the making and renewal of acquaintance.

The first formal function took place the next morning, Tuesday, the 16th, at Westminster Abbey. The heat of the day was excessive. It would have been excessive even in Washington, and in London it was almost overpowering. The majority of the delegates wore academic dress, and the service was attended by many distinguished Englishmen high in rank or in political service, one of the naves of the cathedral being reserved for delegates, the remainder of the space being filled by London society. Addison's superb hymn, "The Spacious Firmament on High," was sung by the choir, and, while appropriate to the occasion

in other respects, brought a smile to the lips of the American delegates when the words were chanted.

The unwearied sun, from day to day,
Does his Creator's power display,
And publishes to every land
The work of an almighty hand.

The service was impressive in the extreme, and most significant was the short address of the Dean of Westminster based on the passage "But truth abideth and is strong forever." He recalled the perturbation which was wont to take possession of men's minds during the last century with regard to discoveries in natural science—perturbation which sometimes betrayed itself in fear, impatience and indignation; but times were now changed; he thought that he might claim to speak in the name of the whole world of contemporary Christian thought when he gave expression to the gratitude, which as a rule the clergy has little or no opportunity for offering, for the amazing enrichment of human thought which had resulted from patient researches into natural science during the past 250 years, and in particular during the past 80 years. They thanked God for the great and glorious work that had been done by the men of science for the widening of human thought; with all humility they expressed their grateful obligation for the benefits which had been rendered in Great Britain by the Royal Society.

In the afternoon of Tuesday, delegates were received in the great library of the Royal Society, Burlington House. Sir Archibald Geikie, the President, was accompanied by Lord Rayleigh, Past President; Sir A. B. Kempe, Treasurer; Sir Joseph Larmor, and Sir J. R. Radford, Secretaries; and Mr. Robert Harrison, Assistant Secretary. The majority of delegates wore official robes or academic dress. Among the scarlet doctors' gowns were prominent the crimson and gold cloaks of some of the German professors, the claret and gold uniform with brown fur cloak of a Hungarian delegate, the inconspicuous but rather bizarre olive-green uniform of members of the French Academy; and the silk robes and turbans of the Indian representatives. The heat again was almost overpowering, and, although the library is called "the Great Library" the 300 delegates were so closely crowded that it required the intense interest of the function to overcome the feeling of personal discomfort.

Sir Archibald Geikie, the President, in welcoming the delegates, was necessarily obliged to make the rather trite but none the less true observation that no more striking proof than was presented by this assembly could be given of the reality and cordiality of that spirit of frank and loyal coöperation which united into one great brotherhood the students of science in every land and in every language. He reviewed the events which led to the grant of the Charter of Incorporation by Charles II, and mentioned some of the famous names of men associated with the Royal Society and with the progress of science. Starting its career with a notable group of physicists and mathematicians, among whom

were Robert Boyle and John Wilkins, it before long welcomed Isaac Newton into its ranks, published his immortal "Principia," and annually elected him as its President for nearly a quarter of a century. He called attention to the fact that the physical sciences had all along been strongly represented in the Society. It seemed but yesterday, he said, that James Clerk Maxwell's voice was heard in those rooms and that Stokes and Kelvin sat in the presidential chair; that the succession of leaders was still well maintained, he called attention to the presence that day of Lord Rayleigh, Sir William Crooks, Sir Joseph Thomson, Sir Joseph Larmor, and any others. Nor had the biological sciences been less prominent in the work of the Society. From the early days of John Ray down to those of Charles Darwin, Hooker, Huxley and Lister, every branch of biology has been illustrated and advanced by the fellows of the Society.

The ceremony of presenting addresses of congratulation followed. Aside from the formal addresses there were speeches of complimentary character from a representative of each country. For America, Prof. W. B. Scott, of Princeton, as Vice-President of the American Philosophical Society, was selected. A notable incident of this function was the presentation to the Society by the German academies and societies of a large bronze tablet commemorative of the work of the Royal Society and of the admiration held for it in Germany. This tablet is to be set into the walls of the Library at Burlington House.

At night on Tuesday a banquet took place at the Guildhall. The delegates were all present, and hundreds of men prominent in most walks of life in England graced the function by their presence. A glance over the table list shows many familiar names, from which are culled here and there a few which may be of especial interest to members of the Washington Academy: Lord Allerton, Lord Alverstone, the Archbishop of Canterbury, the Archbishop of York, Mr. Asquith the Premier of England, Mr. Balfour, Cardinal Bourne, Mr. Francis Darwin, Sir George H. Darwin, the Dean of Saint Pauls, the Dean of Westminster, Prince Ahmed Fouad Pacha, Prince Boris Galitzin, Sir Archibald Geikie, Lord George Hamilton, Mr. Rudyard Kipling, Lord Morley, the Duke of Northumberland, Sir William Osler, Sir William Ramsay, Lord Rayleigh, Lord Reay, Hon. Walter Rothschild, Professor Schaefer President of the British Association for the Advancement of Science, Lord Strathcona, Lord Sudeley, Lord Tennyson, Sir William Thisleton-Dyer, Sir J. J. Thomson, and Sir. J. I. Thornycroft.

Wherever one glanced around the assemblage his eye fell upon some man of world-wide fame.

At the conclusion of the dinner there was an extraordinary list of toasts and responses. The word "toast-master" in England at a function of this kind has a different significance from the term as applied in this country. There the toast-master is literally an announcer of toasts. On this occasion he was a very large man with a very large voice, who announced in stentorian tones at the request of the presiding officer the toasts which were to be drunk, invariably beginning "My lords and gentlemen."

A notable speech was that of Mr. Asquith, Prime Minister of England. It was historical in large part. One sentence which aroused laughter was as follows: "When the universities were ingrossed in the din of civil war, 'to the neglect,' as a contemporary writer says, 'of academical studies,' science and philosophy took refuge in the comparative peace and tranquility which the streets of the City of London could then afford." Another pleasantry of the Prime Minister's was given in the following words: "In the same roll with John Dryden is one of the chief victims of his satire, George Villiers, Duke of Buckingham, who, amid his various qualifications for the chief office of state, was as we know 'chemist, fiddler, statesman, and buffoon,' and I see from your records that history tells us that when this, perhaps the most original of the original fellows of the Royal Society was committed to the tower, a special laboratory was fitted up for him in order that he might practice chemistry; and, according to Bishop Burnet, he was 'nearly' successful in discovering the philosopher's stone—an illustration which suggests that some people might be more profitably employed at present than at either Westminster or Whitehall."

Characteristic of the address of the Prime Minister was the frank acknowledgment of the benefits derived by government from the work of men of science. The administration of the grants of the Royal Society is not, he said, a benefit conferred on the Society by the State, but a service conferred on the State by the Society.

That distinguished scholar and late eminent politician, Lord Morley, proposed the toast of universities at home and abroad, and his address was a most scholarly and able production.

The Archbishop of Canterbury proposed the toast of the learned societies in the old and new world, and called attention to the significance of the fact that this toast had been entrusted to an ecclesiastic. He called attention to the fact that Smithfield and St. Paul's Cross were very near to the Guild Hall, and he believed that the time might be found when, if under that roof or under the roof which preceded it, they had seen a great gathering of orthodox ecclesiastics together with a gathering of adventurous students of science, they might have agreed that they were on the way to Smithfield, that the one might see the other suffer.

One of the speakers at this historic dinner was a member of this Academy, Dr. R. S. Woodward, President of the Carnegie Institution of Washington.

The morning of Wednesday, July 17, was devoted to visits to places of interest in London, including the Zoological Gardens, the British Museum, the Natural History Museum, Victoria and Albert Museum, Lambeth Palace, and Westminster Abbey. The most perfect arrangements were made for the entertainment of the ladies accompanying visiting delegates, and during this and the following mornings arrangements had been made for small parties to see many of the famous private houses of London, and a special reception was held in their honor.

In the afternoon of this day the Duke and Duchess of Northumberland gave a garden party at Syon House on the Thames, about eight miles from Hyde Park Corner—Syon House, one of the famous houses of England, with beautiful grounds, containing a wealth of art. Hundreds of London society people also attended the garden party.

In the evening one of the famous conversaziones of the Royal Society was held at Burlington House. The contrast between a conversazione of the Royal Society, from the social point of view, and one of the social functions of the Washington Academy of Sciences is striking to say the least. Wealth, beauty, and nobility abound at the one, while at the other the list is restricted to scientific attainments and personal beauty.

At Burlington House on Wednesday night, among other interesting exhibits, there were shown the chronometer by Arnold, used by Captain Cook on his second and third voyages; an electrical machine constructed by Doctor Joseph Priestley, the original model of Sir Humphrey Davey's miner's safety lamp, a pair of compasses which belonged to Sir Christopher Wren, and Newton's original account of his reflecting telescope.

Thursday morning also was devoted to specially conducted visits to points of interest, and in the afternoon His Majesty the King, Patron of the Royal Society, and Her Majesty the Queen received the President and Council of the Royal Society and the delegates at Windsor Castle. This was a function that commanded especial interest from the foreign delegates, and, curiously enough, especially from those coming from countries whose governments are of the republican form. The invitations alone, issued by the Lord Chamberlain at the command of their Majesties, and the cards of entrance signed by Chesterfield, Lord Steward, were sufficiently novel to the republicans to demand their vivid interest. Special trains from Paddington Station took the delegates to Windsor, and on their arrival at the famous castle they were conducted through the rooms by Lord Chesterfield, and eventually formed in line upon the Rose Terrace. Finally the King and Queen appeared descending the staircase, and stood alone at its foot. Several personalities, including King George of Greece, stood carelessly upon the staircase above watching the proceedings. The delegates, 300 in all, were grouped according to countries, and passed in single file, each receiving a warm grasp of the hand and some of them a pleasant word or so from both the King and Queen. One of the members of the Washington Academy of Sciences, namely Major Squier, now military attaché to the United States Embassy at London, and on this occasion representing the Franklin Institute of Philadelphia, received an especial word of greeting from the King, with whom he had had a long personal interview a few days before on his arrival in London to assume his diplomatic position.

Following this reception by the King and Queen, the delegates descended to the gardens below, where a gigantic garden party, attended

by nine thousand of England's best, was assembling. It was a beautiful day; the weather had grown milder although still bright and sunny. The wonderful of green the English trees and turf—the brilliant colors of the summer costumes of the women—the variegated refreshment marquees—the beautiful strains from several military bands—the sound of the charming English voices as one passed from group to group—the feeling that one had that he was mingling with the best that England could produce in culture, in scientific attainment and social position—altogether produced an exalted condition of mind not to be forgotten.

This royal reception at Windsor brought the celebration to a close so far as the official arrangements of the Royal Society itself were concerned, but, realizing that among the fellows there was a strong desire to offer to their guests from foreign lands and from the British dominions over the seas some less formal and more intimate hospitality, a numbers of the fellows gave private dinners, more or less especially to include those guests who brought their wives and daughters with them, while the Royal Society Club invited the rest of the foreign and colonial delegates to dine at the famous Trocadero Restaurant. At this last dinner no speeches were made.

On Friday visits were made to Oxford or Cambridge, as the delegates preferred. Convocations were held at each of the universities, and luncheons were given to the guests. At both universities honorary degrees were conferred, and at Oxford, among others, Dr. W. B. Scott, Blair Professor of Zoology and Paleontology in Princeton University, was given the honorary degree of Doctor of Science. At Cambridge Dr. E. B. Frost, Director of the Yerkes Observatory, among others, was given the same honorary degree.

The writer had on previous occasions met with the charming hospitality of the English, and he had had opportunity to witness their genius in the organization of scientific meetings and international congresses and celebrations; but never had he met with such perfection of arrangement, such wealth of hospitality, and never had he been given such an insight into many of the qualities which place the England of today in the high position which she occupies among nations as on this occasion, and he dare not hope for another similar opportunity in one lifetime.

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 464th regular meeting of the Anthropological Society of Washington, D. C., was held December 17, 1912, at the National Museum, the President, Mr. Stetson, in the chair.

Prof. C. V. Piper read a paper on *The Filipinos and the problem of their government.* He began with a general résumé of the insular conditions and various peoples dwelling there, of whom he said the Negritoes, now found mainly in four islands but once in nearly all, are generally regarded as the original inhabitants, the Igorrotes and other wild tribes

being the next to arrive, the Filipinos next, perhaps about 500 A.D. and the Moros last, about the time of the Spanish occupation. At some length he described the Filipino characteristics, distinguishing between the small educated minority and the majority of ignorant laborers. The most remarkable thing we are doing there, he said, is the attempt, for the first time in history, to educate an inferior people en masse. The Asiatic European colonies have little faith in its success.

Dr. Riley B. Moore read a paper on *Observations in St. Lawrence Island*. This island in the Bering Sea includes one hundred by thirty miles of treeless swamp and tundra inhabited by some two hundred and fifty people, the débris of five different tribes. Some of these resemble Sioux Indians; others are typical Mongolians, with all intervening kinds. In summer they have a profusion of birds and fish to feed on; but in other seasons their food is whale-meat, seal-meat and walrus-meat. They live with little ventilation and suffer from many skin diseases. Tuberculosis also is very common. The death rate has long exceeded the birth rate.

Wm. H. Babcock, *Secretary*.

## THE CHEMICAL SOCIETY OF WASHINGTON

The 217th regular meeting was held on October 10, 1912, at the Cosmos Club. The general subject for the evening comprised reports on the meetings of the Eighth International Congress of Applied Chemistry. President Le Clerc reported on the international meetings, addressed by Bertrand, Duisberg, Eyde, Perkin, and Ciamician. Experiments were shown by the speaker illustrating Perkin's success in fire-proofing cotton fabrics.

F. K. Cameron reported on agriculture and silicate industries. The most important papers of the Congress, in his opinion, were concerned with the fixation of nitrogen. F. W. Clarke reported on atomic weights and sketched the history of the International Commission. W. D. Bigelow summarized the papers on bromatology and hygiene, paying especial attention to those on analytical methods, metabolism, and preparation of foods. H. E. Patten reviewed the electrochemical papers in all the sections. The papers on dust collection, sulfuric acid, and new alloys of tungsten and the iron group were given especial attention by A. L. Day in reviewing the sections on inorganic and physical chemistry. Finally, C. E. Munroe spoke very interestingly of new developments in explosives brought out in the section on that subject.

A special meeting was held on October 24, 1912, at the Cosmos Club. The following papers were read:

*Moisture determination by means of calcium carbide:* H. C. McNeil. The apparatus used was briefly described and examples of determinations in a wide variety of substances were given. The method gives results concordant within 0.2 per cent on quantities of the order of 15 per cent. Discussion by Tolman.

*Study of changes taking place in the conversion of cider into vinegar:* L. M. TOLMAN The conversion of a large quantity of cider into vinegar was followed in a large factory in Michigan. The only important change that occurs is the conversion of the alcohol into acetic acid, the other substances present remaining nearly the same. The raw material, altho varying from year to year, is remarkably uniform in composition in a given year. No general conclusions can be drawn from analyses of home-made vinegars, which vary quite widely.

In the discussion by Gore the fact was brought out that the yield is about 73 per cent of the theoretical. Alsberg and Seidell also discussed the paper.

*Potassium ammonomagnesate and potassium ammonobarate:* E. C. FRANKLIN. The ammonia system of acids, bases, and salts was outlined, and the analogy carried on into the amphoteric compounds of zinc, lead, etc. But cuprous copper, thallium, barium, and magnesium also act as amphoteric elements in the ammonia system, and the salts named in the title are among those recently prepared. The speaker showed the apparatus and described the methods of manipulating these compounds. Discussion by Foster, Johnston and Cameron.

The 218th regular meeting was held on November 14, 1912, and was devoted to the election of officers for 1913 as follows: President, C. E. WATERS, Bureau of Standards; First vice-president, M. X. SULLIVAN, Bureau of Soils; Second vice-president, C. L. ALSBERG, Bureau of Plant Industry; Secretary, R. B. SOSMAN, Geophysical Laboratory; Treasurer, F. P. DEWEY, Bureau of the Mint; Councilors, C. L. ALSBERG, Bureau of Plant Industry; S. F. ACREE, Johns Hopkins University; P. H. WALKER, Bureau of Chemistry; J. A. LE CLERC, Bureau of Chemistry; Executive Committee, J. JOHNSTON, Geophysical Laboratory; E. W. BOUGHTON, Bureau of Chemistry; R. C. WELLS, Geological Survey; E. C. MCKELVY, Bureau of Standards.

ROBERT B. SOSMAN, *Acting Secretary.*

The 219th meeting was held jointly with the Baltimore Branch of the American Chemical Society in Hokpins Hall, Baltimore, on November 30, 1912. The following papers were read:

*The inflammability of coal dust:* J. C. W. FRAZER. Discussion by C. Caspari, Jr., W. A. Randall, B. F. Lovelace, Marshall, Roundtree, and J. A. LeClerc.

*The United States Pharmacopoeia, its origin, history and requirements:* CHARLES CASPARI, Jr. Discussion by Englehardt and Le Clerc.

C. P. VAN GUNDY, *Secretary pro tem.*

The 220th meeting of the Chemical Society was held 12 December, 1912, at the Cosmos Club. President-elect C. E. Waters was elected vice-president of the Washington Academy to represent the Society. The following papers were read:

R. B. DOLE of the Geological Survey: *The concentration of mineral waters in relation to their therapeutic activity.* The efficacy of the waters

of health resorts usually arises from other causes than the composition of the water. The reactions of substances usually present in the mineral waters are those of the positive or negative salt radicals. Their effect can therefore be predicted by the experimental use of single pure salts in solution at known concentrations. The following phenomena interfere with simple deduction from such experiments: (1) cumulative effects of certain radicals; (2) "toleration" acquired against certain radicals; (3) "interference" of different radicals in the same water. Examples of very concentrated waters in common use in the West were cited, to show that waters having concentrations well above the normally active physiological dose could be used for years with no appreciable effect.

F. C. Cook, of the Bureau of Chemistry: *A comparison of plant, meat, and yeast extracts.* The paper was concerned largely with methods, and can not be briefly abstracted.

*Discussion:* Alsberg suggested that removal of ammonia or presence of some unrecognized compound would result in better agreement between the Van Slyke and Soerensen methods for hydrolyzed proteins. M. X. Sullivan discussed the presence of small amounts of creatinin in plants, probably too small to affect the test for distinguishing plant from meat extracts. E. C. Franklin also discussed the paper.

A. S. Cushman and E. B. Wettengel of the Institute of Industrial Research: *The electrolytic determination of tin in canned food products.* Read by Mr. Wettengel. The usual gravimetric method for tin is tedious and expensive. The electrolytic method is much simpler and shorter and was shown by thoro tests to give reliable results. The pulped material is digested with acid, neutralized with ammonia and ammonium sulfide, freed from insoluble matter, and electrolyzed hot, using a rotating cathode. Discussion by Taber and Smith.

A. Seidell of the Hygienic Laboratory and F. Fenger of Armour and Company: *Seasonal variation in the iodine content of the thyroid gland.* Read by Seidell. A parallelism exists between the iodine content and the physiological activity of commercial thyroid as used in medicine. A standard commercial concentration of 0.2 per cent has been recommended. In order to obtain data upon the raw material used in manufacturing commercial desiccated thyroids, and to study the possibility of meeting such a standard, Mr. Fenger collected samples at Chicago from sheep, hogs, and cattle at two-week periods, each representing about 300 animals. Maxima of iodine were found in all three between September and November, and minima in summer. A rather variable ash content was found due to the wear of the ball mills.

*Discussion:* Waters suggested that the iodine content varied with the amount of green food. Seidell believed this was not the only cause of variation. Dole suggested a geographical variation, which was admitted as a possible explanation in spite of the large number of samples. Alsberg added further evidence of a geographical variation. Bunzel quoted the determinations of Koch to show a seasonal variation. Dole

stated that no potable waters in this country have enough iodine to have any effect in preventing goitre, if a lack of iodine is the cause of that disease. Cook quoted his analyses of corals, showing a selective absorption of iodine by these organisms.

ROBERT B. SOSMAN, *Acting Secretary.*

## THE BOTANICAL SOCIETY OF WASHINGTON

The 85th regular meeting of the Botanical Society of Washington was held at the Cosmos Club, Tuesday evening, January 7, 1913. The following scientific program was presented:

DR. DAVID GRIFFITHS: *Performances in species of opuntia* (illustrated with lantern slides). This paper will be published in the near future as a bulletin of the Bureau of Plant Industry.

MR. J. B. NORTON: *Some interesting facts concerning the genus Asparagus* (illustrated with lantern slides). This paper gave a review of features connected with the work of breeding a rust resistant variety of asparagus. *Asparagus officinalis* has never been found to be completely immune to the attacks of its rust, *Puccinia asparagi.* Plants nearly immune to the destructive summer stages show no resistance to the aecidial stage of the fungus. Resistance seems to be due to morphological causes. Related species are attacked by the rust but the members of other sections of the genus seem immune. The genus Asparagus and its relatives are entirely limited to the old world, the majority being African. A study is being made of the relationships of this group and many new characters based on the manner of growth, roots, stems, leaf scales, cladodes, etc., have been found. The arrangement of the stomata on the cladodes is very characteristic in the various groups. The old genus Asparagus contains several very distinct groups of species entitled to generic rank.

Only one hybrid form of known parentage has been secured, a cross between *A. officinalis* and *A. davuricus.* Many other combinations have failed to produce seed. Asparagus grows rapidly,—some species average nine inches per day. The seed germination takes from twelve days with *officinalis* to sixty or more days with some African species. Several new ornamental forms were described.

C. L. SHEAR, *Corresponding Secretary.*

THE PROCEEDINGS

OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str.. Berlin.

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# JOURNAL

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RADIOTELEGRAPHY.—*The measurement of received radiotelegraphic signals.* L. W. AUSTIN, U. S. Naval Radiotelegraphic Laboratory.

(A) *A tester for rectifying contact detectors.* The measurement of radiotelegraphic signals at a great distance from the sending station is complicated by the fact that the most common type of detectors, the contact rectifiers, can not in general be depended upon to give the same sensitiveness at all times. This type of detector has a great advantage over others for quantitative work, inasmuch as it can be used with a galvanometer as well as with the telephone. Experience shows that the loudness of signal in the telephone as measured by the shunt method is exactly proportional to the deflection of a galvanometer placed in the same circuit, and in the case of nearly all types of rectifiers proportional to the square of the oscillatory current. In a former article[1] I have described a method of calibrating the detector in terms of received current in the antenna. This method, while highly satisfactory in a laboratory or large station with more or less laboratory equipment, is not suited to the use of the ordinary operator and quite impossible for use on shipboard since it involves necessarily two highly sensitive galvanometers and somewhat fragile thermoelements.

In order to overcome these difficulties I have arranged a form of detector tester which serves to establish the sensitiveness of any rectifying detector at any given time. The principle of the

[1] Bulletin, Bureau of Standards, 7: 295. 1911.

apparatus is as follows: A buzzer-driven circuit of fixed inductance and capacity has its high frequency current square measured by a sensitive H. & B. hot wire watt meter giving full scale for 0.03 watt. To the buzzer-driven circuit is coupled a second circuit with fixed condenser and two fixed inductances tuned to the buzzer circuit. This intermediate circuit is introduced to prevent any direct effect of the buzzer on the detector. To this second circuit is coupled with a fixed coupling a third circuit consisting of a fixed inductance, stopping condenser and the detector to be tested. A Paul microammeter of about 250 ohms resistance, giving two divisions per microampere, is placed around the stopping condenser in series with the telephones regularly used with the detector.[2] The plan of the apparatus is shown in the figure, and the value of the inductance and capacities are shown in the table.

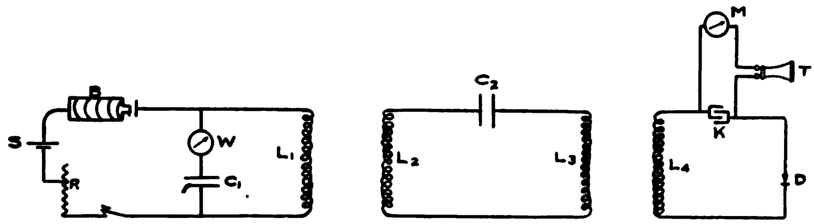


Fig. 1. Radio-Detector Tester

| | |
|---|---|
| *B*, | Ericsson buzzer, 3 ohms. |
| *S*, | 1 or 2 dry cells. |
| *R*, | Variable resistance. |
| $\lambda$ = | 2000 m.[3] |
| $L_1 = L_2 = L_3 = L_4$ | Inductance = 0.4 m.h. |
| $C_1$, | Fixed air condenser = 0.0028 m.f. |
| $C_2$, | Fixed air condenser = 0.0014 m.f. |
| *W*, | H. & B. hot wire wattmeter, 6.5 ohms. |
| *M*, | Paul Microammeter, 250 ohms. |
| *T*, | Telephones 2500 ohms. |
| *D*, | Detector under test. |

[2] The object of placing the telephones in the circuit is to ensure an approximately normal amount of resistance in series with the detector.

[3] Shorter wave lengths do not give enough energy to be measured on the wattmeter without using too much current thru the buzzer contact.

It will be seen that this detector tester differs from others in that the wave lengths, inductances, coupling, etc., are fixed and the test becomes simply the measurement of the response of the detector to a definite amount of high frequency excitation.

The sensitiveness of the detector is determined by observing the deflection on the microammeter corresponding to a reading of 0.005 watt on the wattmeter in the buzzer circuit. The ratio of wattmeter to microammeter reading may be expressed in terms of energy required to produce a response, arbitrarily taken as the least audible signal under average conditions. This energy calibration of the detector tester is made once for all by means of a detector calibrated immediately before by the thermoelement and galvanometer method.

For example, a certain detector, which by the method already mentioned[4] has been shown to require $3.1 \times 10^{-9}$ watts to produce an audible sound in our standard laboratory telephones, produces when placed in the tester a deflection of ten divisions on the microammeter for a reading of 0.005 watt on the buzzer circuit wattmeter. Now, if some other detector be placed in the tester and gives five divisions for the same wattmeter reading, it is half as sensitive as the first and requires $6.2 \times 10^{-9}$ watts for audibility in the standard telephones.

Experience has shown that the amount of energy required to produce a certain strength of signal from the detector is independent of the wave length and approximately independent of the spark frequency.[5] It has also been found that, when the detector circuit is coupled to the antenna just closely enough to produce maximum strength of signal, the energy is equally divided between the antenna and the detector circuit.[6] From this it follows that, if we know the energy in the detector, we have a measure of the received energy and, if the total resistance of the antenna, including that introduced by the coupled detector circuit be known, and the effective height of the antenna be also known,[7] from the

[4] Bulletin, Bureau of Standards, 7: 295. 1911.

[5] Entirely so for galvanometer deflection.

[6] Bulletin, Bureau of Standards 7: 301, 1911.

[7] T. Ruedenberg, Ann. d. Phys. 25: 446. 1908. Journal of the Washington Academy, 1: 275. 1911.

strength of signal or galvanometer deflection we can determine at once the intensity of the electric field at the receiving point.

Some detectors, for example the perikon,[8] can not be calibrated with the microammeter as their adjustment is disturbed by the amount of high frequency energy required to make a suitable deflection. For such detectors the following method of calibration may be used. The middle circuit may be opened and leads of about 50 cm. in length brought out to a coil of two or three turns of wire wound on a hard rubber core. On this same core, at a sufficient distance from the first coil to give proper coupling, a second coil of say 0.1 m.h. is wound, and to this coil is connected the detector to be tested with suitable stopping condenser and telephones with an audibility meter of the type described in this paper shunted across them. In this case the audibility meter takes the place of the microammeter of the first method and the coupling should be adjusted and made permanent for an audibility of about 100 times with an average detector for a wattmeter reading of 0.005 watt.

(B) *An audibility meter.* For the determination of the loudness of the signals in the telephone by the shunted telephone method, the most convenient form of shunt resistance box is one in which all the resistances are controlled by a single dial arm. In general, thirty to forty studs are sufficient, giving different degrees of audibility varying by approximately 20 per cent. The exact inductive resistance of the telephone, of course, varies with the spark frequency, and to a lesser extent with the capacity used in the stopping condenser which seems to affect the wave form of the rectified pulses. The inductive resistance of modern 2500 ohm telephones used with a stopping condenser of not more than 0.02 microfarad at a thousand sparks per second, is approximately 5000 ohms. With the old fashioned low frequency spark, the inductive resistance differs very little from the direct current resistance. If the resistance box is made for use with a definite telephone and a definite spark frequency it may be very conveniently marked in audibility instead of in resistance.

[8] The silicon on the contrary is very stable.

The following are the values of the resistance units and corresponding audibility for 2500 ohm telephones at 1000 sparks per second in an audibility meter designed at my suggestion by G. W. Pickard:

| AUDIBILITY | RESISTANCE | AUDIBILITY | RESISTANCE |
|---|---|---|---|
| | *ohms* | | *ohms* |
| 2 | 5000 | 100 | 51 |
| 2.5 | 3300 | 120 | 42 |
| 3 | 2500 | 160 | 31 |
| 4 | 1650 | 200 | 25 |
| 5 | 1250 | 250 | 20 |
| 6 | 1000 | 300 | 16.7 |
| 8 | 720 | 400 | 12.5 |
| 10 | 555 | 500 | 10.0 |
| 12 | 455 | 600 | 8.4 |
| 16 | 334 | 800 | 6.3 |
| 20 | 264 | 1000 | 5.0 |
| 25 | 208 | 1500 | 3.3 |
| 30 | 174 | 2000 | 2.5 |
| 40 | 128 | 3000 | 1.7 |
| 50 | 102 | 4000 | 1.3 |
| 60 | 85 | 5000 | 1.0 |
| 80 | 63 | | |

MINERALOGY.—*A danger to be guarded against in making mineral separations by means of heavy solutions.* W. F. HILLEBRAND, Bureau of Standards. To appear in the American Journal of Science and the Zeitschr. Kryst. Mineral.

The occasional action of heavy solutions on minerals is usually evident to the eye. When using Thoulet's solution of mercury and potassium iodides to separate from its gangue a carnotite from Paradox Valley, Montrose County, Colorado, carrying calcium instead of potassium (probably identical with the tuyamunite of Nenadkevich,[1] the author found that the calcium of the mineral was largely, if not wholly, displaced by potassium, without visible alteration, altho Mr. H. E. Merwin observed a large decrease in the optic axial angle to have resulted. The observation shows how important it is to assure oneself, when using heavy solutions, that such chemical changes are not incurred. Question

[1] Bull. Acad. Sci. St. Petersburg, 1912, p. 945.

arises as to the validity of some formulas that have been assigned to minerals which have been separated by heavy solutions.

The calcium carnotite will be described in detail by Mr. Merwin and the author in a later paper.

MINERALOGY.—*Two varieties of calciovolborthite* (?) *from eastern Utah.* W. F. HILLEBRAND, Bureau of Standards, and H. E. MERWIN, Geophysical Laboratory. To appear in the American Journal of Science and the Zeitschr. Kryst. Mineral.

Descriptions in some detail will appear in the above named journals of two hydrous minerals, one essentially a vanadate of copper, the other an arsenovanadate of copper and calcium. The minerals were briefly mentioned by J. M. Boutwell in Bulletin 260 of the U. S. Geological Survey a number of years ago, but analyses were not published. Better material not being forthcoming the analyses are now put on record, together with results of recent optical study. For the present both minerals are referred referred to calciovolborthite, since the molecular ratios show closer relationship to that imperfectly described species than to any other. One variety is yellow green, with little arsenic, the other, highly arsenical, is greenish yellow. The latter is pseudomorphic after the former. The locality of occurrence is Richardson, in the canyon of the Grand River, Utah.

BOTANY.—*Ivory palms in Panama.* O. F. COOK, Bureau of Plant Industry.

New materials for the study of the ivory palms (Phytelephantaceae) have become available in the collections of economic plants secured in Panama in 1911–12 by Prof. H. Pittier of the United States Department of Agriculture. The series is more extensive than any obtained by previous explorers and throws light on the geographical distribution, morphology and classification of this long-neglected family. It may be that special students and collectors of palms have felt at liberty to neglect the ivory plants because some botanists have denied that Phytele-

phas is really a palm, tho there is no adequate reason for such a separation. The nearest relatives of Phytelephas are to be found in other American families, such as the Cocaceae and Manicariaceae, whose status as true palms has never been questioned.[1]

### GEOGRAPHICAL DISTRIBUTION OF IVORY PALMS

The new specimens from Panama were obtained in four different localities; two near the Caribbean Coast, one near the middle of the Isthmus and one near the Pacific Coast. In each case a different species was secured, and all four of the species appear to be different from two others previously represented in the Economic Herbarium of the Department of Agriculture. In addition to the places where specimens were collected Professor Pittier heard reports of the existence of ivory palms to the north of the Isthmus, and this information is substantiated by Dr. A. E. Heighway of Bocas Del Toro, Panama, who states that ivory palms exist in small numbers in several places, most of them back a few miles from the coast, along the foothills. Thus it appears that the geographical distribution of the ivory palms extends beyond the Isthmus, so that the family Phytelephantaceae must be included in the flora of North America.

The genus Phytelephas was based originally on two Peruvian species, from the eastern slopes of the Andes. One species has been described from the Pacific coast of Ecuador and another from the Magdalena Valley of Columbia. Thus only four definitely localized species are known from South America to six in the region of Panama. The existence of so many local species in the narrow limits of the Isthmus makes it seem probable that more careful study of the South American members of the group will result in the discovery of a much larger number of specific forms. Even on general biological grounds it would not be expected that species with such large heavy seeds would retain their continuity over wide areas of distribution. The first requirement for an adequate taxonomic treatment of the group is to

[1] O. F. Cook, Relationships of the ivory palms. Contributions U. S. National Herbarium **13**: 133. 1910.

learn the characters which enable the species to be distinguished. In this respect the materials from Panama are of special value for they show several new lines of specialization not previously employed in the diagnosis of species.

## NEW CHARACTERS IN IVORY PALMS

*External sculpture of fruits.* The species are all alike in having the external shell of the fruit divided into raised polygonal areas, each bearing a pyramidal tubercle or spine, but the areas are larger in some species than in others and have larger or more robust spines. In coarsely sculptured species the spines attain a length of about 2 cm.; in other species they are only half as long.

*Cortical fibers.* These form a lining of close-set bristles on the inner wall of the external shell of the fruit, to which they are firmly attached. Indeed, the shell seems to be formed by a progressive hardening of the corky tissue in which the bases of the fibers are embedded. The species differ notably in the development of the cortical fibers, some having only short weak fibers and others long stiff fibers. In most cases the fibers are about as long as the external spines, but they may be longer or shorter.

*Pulp fibers.* The space between the cortical fibers and the true mesocarp fibers that form a coating around the nuts is occupied at first by a fleshy pulp. In some species the pulp seems to be entirely fleshy, so that only an empty space is left inside the cortical lining after the pulp has disappeared. In other species there is an open framework of loosely connected fibers, especially near the base of the fruit.

*Mesocarp fibers.* In addition to the pulp fibers there is a complete fibrous sheath around each of the nuts, not unlike the mesocarp of some of the cocoid palms, except that the fibers are not attached to the shell of the nut. Some species of ivory palms have the mesocarp fibers rather coarse and stiff, while in others they are very fine and thin and are compacted into a fabric, tough in some cases and brittle in others. Finally there are cases where the mesocarp fibers are so slightly developed that no coherent layer is formed and the dried pulp breaks away from the surface of the nuts in angular scales. The mesocarp sheath may

be closely adherent to the endocarp or shell of the nut, or free and readily separable from the nut. One species has the sheath much larger than the nut as though separated in the fresh state by a layer of pulp.

*Style.* In most of the species the style disappears in advance of the maturity of the fruit, but one of the new species from Panama has a persistent woody style.

*Columella.* Most of the species have a short column or bundle of compacted fibers suspended from the center of the cortex of the fruit in the position of a placenta. The species with the persistent style also has a more specialized, persistent columella extending down between the nuts nearly to the position of the hilum.

*Hilum.* The hilum is very prominent in some species and nearly flat in others. The shape differs from long oval or elliptical to nearly round. The fibrovascular pits are irregular and scattered over the surface of the hilum in some species while in others the pits are nearly round and confined to a relatively small area in the middle of the hilum.

*Adhilum.* This name is applied to a peculiar specialization of the shell of the nut to form a distinct process or spine at the upper angle of the margin of the aperture, close to the hilum. In some species the adhilum is a small rounded prominence or angular tooth, but in other cases it is developed into a slender acicular spine. The adhilum is formed of the same hard material as the shell of the nut, but is so brittle that it is usually broken off in removing the mesocarp, which may explain why it has not been noticed before.

*Seed coats.* The shell of the nut has a lining of fine fibrous material through which the branches of the raphe are distributed. In some species this lining is free from the true seed coat and in others completely united with it. In the former case the branches of the raphe are not exposed, but appear as raised veins on the lining of the shell. In the latter case the branches of the raphe are exposed on the kernel as it comes from the shell, because the fibrous lining is torn apart into two irregularly separated layers, one adherent to the inner surface of the shell, the other to the true seed coat.

## DIAGNOSES OF NEW SPECIES FROM PANAMA

*Phytelephas pittieri.* Trunk erect, attaining a height of about 8 meters, with a diameter of about 25 cm.; leaves about 12 with short petioles and about 70 pairs of pinnae equally spaced along the rachis; male inflorescence cylindrical, about 1.20 meters long; male flowers with 300–400 stamens, fruits 8–9 in a head, with large external spines. Collected at Puerto Obaldia, Panama, August, 1911, by H. Pittier (No. 4323); type in U. S. National Herbarium, No. 716082.

*Phytelephas cornutus.* Trunk decumbent, creeping by numerous roots; leaves about 20, with about 90 pairs of equally spaced pinnae; fruits 5–6 in a head, with 6–7 nuts in each fruit; cortex with rather long and slender spines, and a persistent woody style; cortical fibers long and slender, not densely crowded, compacted under the style into a persistent hardened columella about 2 cm. long; pulp and mesocarp fibers only slightly developed, the latter forming a very thin fragile layer adherent to the surface of the nut; hilum surrounded by a prominent margin bearing the adhilum as a long slender spine. Collected in the Rio Fató Valley, near Nombre de Dios, Panama, August 16, 1911, by H. Pittier (No. 4230); type in U. S. National Herbarium, No. 691786.

*Phytelephas brevipes.* Trunk very short; male inflorescence about 15 cm. long; fruits broad and flat, or slightly depressed in the middle, 9 in a head, with 6 nuts in a fruit; cortex with rather coarse robust spines and rather short cortical fibers; pulp fibers distinct, but few; mesocarp fibers abundant, formed into a tough cloth-like sac entirely free from the nut and with an open space between; nuts rather large, usually strongly compressed; adhilum submarginal, transverse, triangular, carinate on the upper face. Collected at Gasapasabana, Upper Mamoni River, Panama, October, 1911, by H. Pittier (No. 4473); type in U. S. National Herbarium, No. 679633.

*Phytelephas brachinus.* Trunk robust, decumbent, attaining a length of about 3 meters and a diameter of about 40 cm.; fruits somewhat rounded or lenticular, scarcely depressed in the middle, but sloping to the sides, 5–6 in a head, with 5–6 nuts in each fruit; cortex with rather small slender spines, cortical fibers very short and weak; pulp fibers slender and sparse; mesocarp fibers very delicate and weak, but forming a rather tough, parchment-like membrane adherent to the bony endocarp; nuts short and with the upper surface sloping outward; hilum small, oval or elliptic, not prominent, with a cluster of small rounded pits near the middle; adhilum represented by a small rounded triangular prominence. Collected at Garachiné, San Miguel Bay, near the south coast of Panama, by H. Pittier; type in U. S. National Herbarium, No. 691785.

*Phytelephas brachelus.* Fruits obconic or obpyramidal, with a strong central depression, 9 in a head, with 6–7 nuts in each fruit; cortex with very short spines, about 0.5 cm.; cortical fibers well developed, attaining a length of about 1 cm.; pulp and mesocarp fibers thin, the latter

rather abundant and forming a rather thick, partly adherent covering of the endocarp; nuts rather long; hilum basal, somewhat prominent, nearly circular, with scattered coarse pits; adhilum represented by a slight swelling above the margin. Supposed to come from Panama, but the locality unknown. Fruit head received from J. R. Smith, Waterbury, Conn., in Economic Herbarium of U. S. Department of Agriculture, bearing U. S. National Herbarium No. 691784.

More extended descriptions with numerous photographic illustrations have been prepared for publication, in connection with a general review of the South American species.

BOTANY.—*A new genus of davallioid ferns.*[1] WILLIAM R. MAXON.

In revising the treatment of the pteridophyta for the second edition of the *Flora of the Southeastern United States* the writer has found it necessary to remove from the genus Odontosoria the species known latterly as *Odontosoria clavata* (L.) J. Smith and to refer it to a new genus, Sphenomeris. The publication of this volume having been delayed, it seems desirable to publish this name elsewhere, since a paper[2] dealing with the species of true Odontosoria (with references to Sphenomeris) is already in proof and may conflict in date of publication with that of the *Flora*.

In the unpublished treatment of Odontosoria just mentioned it is pointed out: (1) That the genus Odontosoria, as recognized by Diels in the Pflanzenfamilien of Engler and Prantl, comprises two sections or subgenera, the first (Eu-Odontosoria) containing rather small species of erect or ascending habit and determinate growth, the second (Stenoloma) containing three nominal species of indefinite scandent growth; (2) that these two groups are entitled to recognition as distinct genera; and (3) that, adopting this view, it is necessary to apply the name Odontosoria to the second group, the large climbing species, rather than to the first, as has been done erroneously by Diels. The grounds for this disposition are then presented, together with a review of the

[1] Published by permission of the Secretary of the Smithsonian Institution.
[2] Contr. U. S. Nat. Herb. 17, part 2 (unpublished).

taxonomic history of Odontosoria in its broad sense and a revision of the American species now properly to be referred to that genus.

The group of species of upright or ascending habit and determinate growth, of which the *Odontosoria clavata* of authors is a familiar example, has no valid name. It may be characterized briefly as follows:

**Sphenomeris** Maxon, gen. nov.

Mainly tropical ferns, with slender creeping hairy rhizomes. Fronds subfasciculate, erect or ascending, of small or medium size; stipes not jointed to the rhizome; lamina 3 or 4 times obliquely pinnate or pinnatifid, the divisions alternate, the ultimate segments strongly cuneate; veins free. Sori terminal at or near the truncate apex of the segments, single or 2 to 4 joined; indusia similar in texture to the opposed leaf-margin, flattish, pocket-like, attached at the base and sides, single at the clavate apices of the veins or, if joined, borne upon a translucent receptacle connecting these.

The type species and apparently the sole American representative of this genus is:

**Sphenomeris clavata** (L.) Maxon
*Adiantum clavatum* L. Sp. Pl. 1096. 1753.
*Davallia clavata* J. E. Smith, Mem. Acad. Turin **5**: 415. 1793.
*Stenoloma clavatum* Fée, Gen. Fil. 330. 1852.
*Lindsaya clavata* Mett. Ann. Sci. Nat. IV. **15**: 64. 1861.
*Schizoloma clavatum* Kuhn, Chaetop. 346. 1882.

A large series of specimens of *S. clavata* is at hand from southern peninsular Florida, the Bahamas, Cuba, Porto Rico and Jamaica.

Two common Old World species may also be mentioned: **Sphenomeris retusa** (*Davallia retusa* Cav.) and **Sphenomeris chinensis** (*Adiantum chinense* L.), both agreeing closely with *S. clavata* in habit.

HELMINTHOLOGY.—*Draconema: A remarkable genus of marine free-living nematodes.* N. A. Cobb, Bureau of Plant Industry, Communicated by Frederick V. Coville.

Few nematodes, if any, are more remarkable than Draconema. From a comparative anatomical point of view it takes rank with the bifurcated Lepidonema. The main features of Draconema are illustrated in the adjacent cut. Though the head end is very peculiar, all its peculiarities are more or less comprehensible. While the cephalic setae, amphids, mouth, oesophagus, and cardia, all present singular features, yet these features are referable to known types of nematode anatomy. Even the sudden loss in diameter behind the oesophagus, tho unique, is understandable on the supposition that unusual flexibility is required in this region owing to some odd habit of life.

In contemplation of the remainder of the anatomy, however, one becomes lost in amazement, and can only speculate on the nature and function of the complicated longitudinal series of lateral and subventral appendages. These appendages are found fully developed on both sexes, young or adult, and must, therefore, have to do with functions exercised at various stages of growth, and without regard to sex.

As we know little of the habits of Draconema beyond the fact that it occurs on or near red marine algae of strands in various parts of the world, speculation concerning the functions of its peculiar organs may be idle. One might suggest that the form of the body indicates possibly that the species inhabit tubes, which they may be imagined to construct, or which they may find already constructed and adapt to their uses. The existence of such a dwelling would harmonize with the expanded head and with the slimness of body behind the neck. Supposing the head end to be thrust out of the tubular home, the advantages of a limber body in seeking food can be readily understood. So too, the series of tubular organs might fit in with such a confined habit of life, and have to do with the construction and repair of the supposed tube; or with locomotion; or with aëration, by producing currents of fresher water inside the tube.

Of great interest also are the adjacent associated internal ventral organs, the details of which suggest the discharge of important functions. These internal structures are rich in chromatin. Their number and distribution indicate that in some way they are definitely connected with the tubular organs.

From a scientific standpoint it is especially desirable that further observations be made on this remarkable nematode.

The following notes relate to the suggested type species of this new genus.

*Draconema cephalata*, n. sp. $\frac{2.}{3.9}\text{—}\frac{5.3}{5.1}\text{—}\frac{12.}{2.2}\text{—}\frac{\overset{77}{\text{-M}}}{4.8}\text{—}\frac{92.2}{2.2}$ 1.5 mm. The transparent, colorless layers of the cuticle are traversed by 800 to 900 plain transverse striae. The striae are rather uniformly fine on the body, but are much coarser on the anterior half of the neck, tho they suddenly cease on the head just behind the amphids.[1]

The fusiform neck ends in a rounded head, set off by the absence of striations. The mouth opening, it would appear, is surrounded by six forward-pointing lips, somewhat longer than they are wide, each rounded in front and supported by a forward-projecting pair of slender chitinous ribs. It is possible that the lips are three in number, and each two-parted. In any case they are so grouped as to form an elevated area on the middle of the head, and are surrounded by six short, forward-pointing setae, having a length about equal to the width of one of the wide cervical annules. The non-striated portion of the head bears numerous arcuate forward-pointing setae of variable size, the largest being half as long as the neck is wide, while the shortest are not very much longer than the minute labial setae already described. The amphids are shaped like the end of a shepherd's crook. Their anterior margins lie close to the lips, their posterior portions near the beginning of the striations. Measured crosswise at the widest part they have a width nearly as great as that of the group of lips when these latter are closed. All the more prominent cephalic setae are on the dorsal side of the head. On the dorsal side of the left amphid, near the striations, there is a pair of stout setae

[1] Proposed new term for the organs hitherto called "lateral organs."

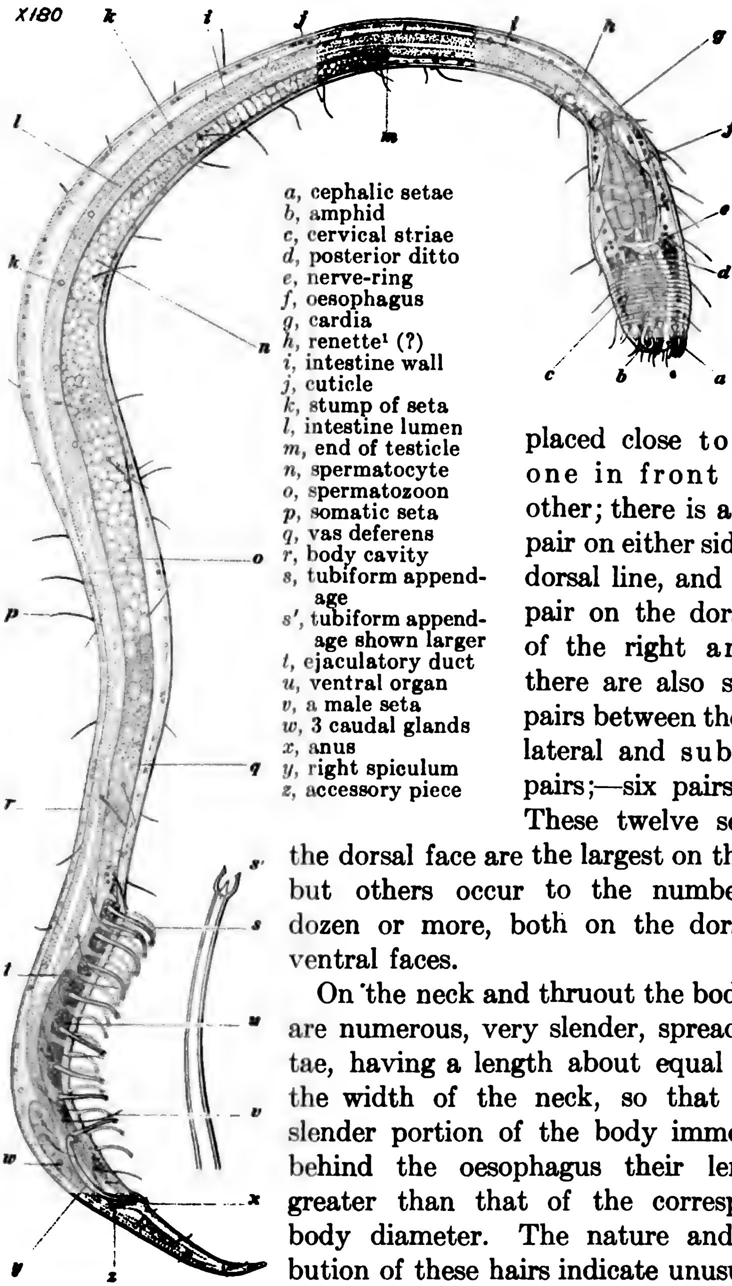


Fig. 1. *Draconema cephalata*

placed close together one in front of the other; there is a similar pair on either side of the dorsal line, and another pair on the dorsal side of the right amphid; there are also similar pairs between these sublateral and subdorsal pairs;—six pairs in all. These twelve setae on the dorsal face are the largest on the head, but others occur to the number of a dozen or more, both on the dorsal and ventral faces.

On the neck and thruout the body there are numerous, very slender, spreading setae, having a length about equal to half the width of the neck, so that on the slender portion of the body immediately behind the oesophagus their length is greater than that of the corresponding body diameter. The nature and distribution of these hairs indicate unusual sensitiveness to external influences.

[1] Proposed new term for organ previously known as the "ventral gland."

There are no eyes.

When the lips are closed the pharynx appears as an elongated, narrow, irregularly fusiform cavity, reaching well into the anterior oesophageal bulb, and ending opposite the anterior cervical striations. The greatest width of the pharynx is about equal to the distance between two successive striations of the adjacent cuticle. Near its hind end it suddenly widens out a little and then contracts again. There are no traces of pharyngeal teeth. The oesophagus is somewhat dumbbell-shaped, and consists of two bulbs connected by a short tube one-third as wide as the neck. The structure of the oesophagus and head suggests that the mouth can be opened widely. The intestine is built of cells of such a size that few are required to complete the circumference—probably two to four.

There are no male ventral supplementary organs of the usual character.

It remains to describe the peculiar series of arcuate tubular organs, found on both sexes on the posterior portion of the body in front of the anus. There are four series of these organs; two lateral and two ventrally submedian. The lateral sets comprise nine pairs. Each organ consists of a colorless, transparent, non-staining, arcuate, hollow tube, curving slightly backwards, but on the whole arranged nearly at right angles to the ventral surface. The outer extremity of each tube is enlarged a little and is distinguished from the remainder of the tube, not only by its width, but by difference in structure, for it is somewhat bell-shaped, and has an axial portion corresponding to the tongue of the bell. The tubes have a diameter about equal to the width of one of the adjacent annules, but are not perfectly uniform in diameter thruout their length, in fact taper gently from base to tip. That portion of the body occupied by the tubular organs is supplied with peculiar internal ventral bodies, the number and position of which correspond, approximately at least, with the number and position of the tubes. It is not that there is one of these bodies to each tube, but rather that all the tubes in the same zone are associated with one of the internal bodies. These cellular bodies are ventral in position and their number is about nine.

The adult female of *Draconema cephalata* is unknown. Females of other undescribed species show the vulva as central and the internal female organs double, symmetrical and reflexed, the rather short ovaries reaching well back towards the vulva. The eggs in these other species are usually prolate and thin-shelled, and few in number, generally only one in each uterus, and appear to be deposited before segmentation begins.

*Habitat.* Marine algae, or sand at their base, shoal in Kingston Harbor, Jamaica; also the strand of a small island off Port Royal, Jamaica.

## ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

PHYSICS.—*A simplified formula for the change in order of interference due to changes in temperature and pressure of air.*[1] IRWIN G. PRIEST. Bulletin Bureau of Standards, vol. 9, in Press.

The author developed independently for use at the Bureau of Standards the following correction formula:

$$K=\left(\frac{b_1}{1+t_1}-\frac{b_2}{1+\alpha t_2}\right)\cdot l\cdot\left(\frac{\mu-1}{380\lambda}\right)$$

where $t_1$ = lower temperature Centigrade, $t_2$ = higher temperature Centigrade, $b_1$ = pressure in mm. of mercury at temperature $t_1$, $b_2$ = pressure in mm. of mercury at temperature $t_2$, $l$ = distance between mirrors, $\mu$ = refractive index at 0°, 760 mm., $\alpha$ = coefficient of expansion of air, $\lambda$ = wave length.

He noticed later that the formula published by Pulfrich,[2] viz:

$$K=l(t_2-t_1)\frac{b_2}{760}\cdot\frac{1}{1+\alpha t_1}\cdot\frac{1}{1+\alpha t_2}\left[\frac{2(\mu-1)\alpha}{\lambda}\right]-l(b_2-b_1)\cdot\frac{1}{1+\alpha t_2}\left[\frac{2(\mu-1)}{760\lambda}\right]$$

could be reduced to this simpler and more convenient form. The derivation of the new formula is given and the two formulas are compared as to convenience in practice. I. G. P.

[1] To understand this abstract the reader must see first Pulfrich. Zeit. für Inst. K. **13**: 456.

[2] The sign in Pulfrich's paper is in error if the expression is to give the *correction* not the *error*.

PHYSICS.—*Note on the calibration of optical pyrometers.* PAUL D. FOOTE. Metallurgical and Chemical Engineering, **11**: 97. 1913.

This note is a suggestion of a method for the calibration or checking of optical pyrometers. The only new feature is the construction of the "black body" upon which the pyrometers are sighted. A small enclosure, turned on the end of a graphite conical tube, dips into a graphite crucible containing 1000 to 1500 grams of molten metal, the pot being heated within an electric resistance furnace. Melting and freezing curves show the proper value to assign to the pyrometer reading, the flat part of the curves corresponding to the temperature of melting or of freezing. P. D. F.

MINERALOGY.—*A study of the tourmaline group.* WALDEMAR T. SCHALLER. Zeits. f. Krystallographie und Mineralogie, **51**: 321–343. 1912.

Analyses of tourmalines from Elba and California are given as well as their crystallographic constants, densities and refractive indices. The correlation of the physical and chemical properties is undertaken and by using also the available published data, the following conclusions are reached: (1) The general formula proposed by Penfield and Foote, namely $H_{20}B_2Si_4O_{21}$, is confirmed. (2) Some analyses do not give enough water to yield the ratio 12 $SiO_2.4H_2O$ but only 12 $SiO_2.3H_2O$. (3) The phenomenon of solid solution (as distinct from isomorphous mixture) does not play any role in tourmaline. (4) The percentages of $Al_2O_3$ and RO vary reciprocally in direct proportion. (5) The mineral tourmaline can not be represented by two, three or four definite formulas. General formulas can be deduced but at least four are required. The number of definite formulas or components, as they may be called, is large, not less than eight and probably more. (6) The crystallographic and physical properties vary in relation to the changes in chemical composition but the trustworthy data available are too meager for an exact correlation. Nevertheless all the determined changes are always in the same direction and approximately of the same order of magnitude, as shown by the diagrams in the original paper. Those tourmalines containing about 35 to 36 per cent $Al_2O_3$ show the maximum specific gravity, refractive indices and double refraction and the longest *c*-axis. W. T. S.

MINERALOGY.—*The crystallography of natramblygonite.* WALDEMAR T. SCHALLER. Zeits. f. Krystallographie und Mineralogie, **51**: 246–247. 1912.

Crystals of natramblygonite ($Na[Al(OH,F)]PO_4$) from Cañon City, Colorado, are described. They are very close to those of amblygonite in their interfacial angles and show similar crystal forms. W. T. S.

ECONOMIC GEOLOGY.—*The commercial marbles of western Vermont.* T. N. DALE. Bulletin 521, U. S. Geological Survey, pp. 164 and index, 2 colored geological maps, with sections, views, diagrams and micro-drawings. 1912.

Altho this bulletin has to do mainly with the calcite and dolomite marbles it includes brief accounts of the Roxbury serpentine and the newly discovered chrome-mica schist marble of Shrewsbury. It comprises a brief manual on marble in general, an account of the local areal, structural and historical geology, and the economic application of stratigraphy and petrography to the marble industry. In the scientific part the origin of dolomite is discussed and new facts are adduced to show that altho dolomitization of $CaCO_3$ does occur some dolomite is probably of direct sedimentary origin. In the economic part the Vermont marbles are standardized as to texture by their average grain diameter by the Rosiwal method and are compared with various European marbles. All the marbles described are classified commercially and scientifically. There are also chapters on values, adaptations, marble machinery, the probable amount of unexplored marble in western Vermont, scientific prospecting for and the testing of marble. Three bibliographies of marble are given, scientific, economic, and local, also a glossary of technical terms. T. N. D.

HEREDITY.—*Heredity and cotton breeding.* O. F. COOK. Bulletin 256, Bureau of Plant Industry, pp. 113, 6 plates, 19 text figures. 1913.

This bulletin attempts to present a more concrete conception of the nature of heredity, and to utilize this conception in the elucidation of practical breeding problems. Many current ideas of heredity derived from the study of self-fertilized plants are not applicable to normally open-fertilized types like cotton and corn. In dealing with such plants the "pure line" conception of heredity as represented by a condition of uniformity and stability of characters should give place to a recognition of diversity and free interbreeding as the normal antecedent condition of heredity and of evolutionary progress.

The uniformity of pure bred groups is an artificial result of restriction of descent to single or narrow lines, not a return to an original stage of purity and uniformity. Selection should be considered as a means of regulating the expression of characters, not of eliminating characters from transmission. Continued selection is necessary to maintain uniformity of expression in improved stocks.

A fundamental distinction between transmission and expression is recognized. The study of heredity, as far as it is concerned with the actual variation of plants and animals, is the study of expression relations. Investigations of heredity instead of being directed so largely to the discovery of the mechanism of transmission should seek first to understand the relations that govern expression. As a step in this direction names are proposed for some of the more important expression relations. When the expression of one character depends upon or conduces to the expression of another character the relation is called "symphanic." When the expression of one character inhibits or interferes with the expression of another the relation is called "antiphanic." When the expression of one character neither favors nor interferes with the expression of another the relation is called "paraphanic."

Other relations of expression are shown by the different results secured in first generation hybrids. In some hybrids there is a blended or combined (mixophanic) expression of the contrasted characters. In other cases one of the parental characters is suppressed (hypophanic), allowing the opposed character to appear as dominant (epiphanic). When both of the parental characters are suppressed, so that a more primitive character appears, the result may be described as reversive or atavistic expression (palimphanic).

Attention is given to the influence of external conditions upon expression, and to the relation of expression to vigor and fertility, including intensification of characters in conjugate hybrids and degeneration in perjugate hybrids. Coherence in the expression of characters derived from the same parental stock is recognized as an obstacle to the formation of Mendelian combinations of characters of different species. Intermediate (metaphanic) expression of characters often involves sterility, not only in hybrids between species, but also in case of incomplete differentiation of specialized organs of the same plant. Thus in cotton bract-like leaves and leaf-like involucral bracts are often accompanied by sterility. The bulletin concludes with two summaries, one of general conclusions regarding the nature of heredity, the other of applications to methods of breeding.

O. F. C.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE WASHINGTON ACADEMY OF SCIENCES

The 81st meeting of the Washington Academy of Sciences, the fifteenth annual meeting, was held at the Cosmos Club, 8 p.m., January 16, 1913, with President F. V. Coville in the chair and 40 members present. The minutes of the previous annual meeting and of all subsequent meetings were read and approved. The reports of the officers, of the Auditing Committee and of the Editors of the Journal were also read and approved.

The report on the ballot by mail for officers for 1913 showed the following elections: President: O. H. TITTMAN; non-resident vice-presidents, JOHN MUIR, F. W. PUTNAM; Corresponding secretary, ARTHUR L. DAY;[1] recording secretary, W. J. HUMPHREYS; treasurer, ALFRED H. BROOKS; managers, class of 1916, VERNON BAILEY, FRED. EUGENE WRIGHT.

The newly elected president, Mr. O. H. Tittman, then took the chair.

The following were elected resident vice-presidents as nominated by the affiliated Societies: Anthropological Society, F. W. Hodge; Archaeological, Mitchell Carroll; Biological, E. W. Nelson; Botanical, Edgar Brown; Chemical, C. E. Waters; Engineers, G. W. Littlehales; Entomological, A. L. Quaintance; Foresters, W. B. Greeley;[2] Geological, T. W. Stanton; Historical, James Dudley Morgan; Philosophical, C. G. Abbot.[3]

On motion by Mr. F. V. Coville, Dr. F. W. Clarke was asked to address the Academy. In reply Dr. Clarke congratulated the Academy on its several activities, and especially on the excellence of its Journal and on its Exhibit of Apparatus, Methods and Results in the New National Museum, March 28, 1912. He also expressed the desire that a similar exhibit be held again this year.

On motion by Dr. L. A. Bauer a vote of thanks was extended to the Business Manager and to the Editors of the Journal for their splendid work of the past year.

The retiring president, Mr. F. V. Coville, then presented his address, *The formation of leaf-mold*, which appears in full in this Journal **3**: 77.

W. J. HUMPHREYS, *Recording Secretary*.

[1] Resigned. G. K. Burgess elected by Board of Managers, January 20, 1913.

[2] Elected by Board of Managers, January 20, 1913.

[3] Elected by Board of Managers, January 20, 1913.

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 465th regular meeting of the Anthropological Society of Washington, was held in the National Museum at 4.30 p.m., January 21, 1913, the president, Mr. George R. Stetson, in the chair.

Dr. Tom A. Williams read a paper on *The dream in the life of the mind.* Dr. Williams said trance, vision, ecstasy and disease delirium are closely allied to the dream state. The psychopathology of them all illuminates formerly uncomprehended diseases. In a dream (illustrated by a case) mental perturbation may crystallize, as it were, and lead to rampageous behavior. On the contrary dreams may be teleologically beneficial; as where a vision saved a young woman from suicide, as was the case also with Benvenuto Cellini.

They are more often a mere reproduction of former experiences more or less significant and more so in psychopathic individuals, such as in a young hysteric who dreamed of falling down wells, assassinations and death, all painful experiences of her childhood.

Dream-thought, apparently confused, is really significant of the mental trend of the individual, when properly analysed and interpreted. One dreams all the time, but recollects only that dreamed within seven minutes of waking. The form of dream can be determined by external stimuli. This is demonstrated in spite of its contradiction by some psychopathologists.

There was no discussion. The meeting then adjourned.

Wm. H. Babcock, *Secretary.*

A special meeting of the Anthropological Society of Washington was held on February 4, 1913 at 4.30 p.m. in the National Museum, the president, Mr. George R. Stetson, in the chair.

Dr. Clark Wissler, Curator of the Department of Anthropology in the American Museum of Natural History, New York, read a paper on *The doctrine of evolution and anthropology.* An attempt was made to distinguish between cultural phenomena on one hand and biological on the other. Especially to make clear that cultural phenomena are not inherited, tho the instinct to develop culture, or to invent, is most certainly inborn. It was suggested that the historical attitude of present-day anthropology should be taken as expressing the cultural point of view. Culture itself seems to be associated with habit complexes or constructs of the mind and not to be in any way innate or inborn, but to be an external affair, preserved and carried on entirely by learning. Cultures develop and have an evolution of their own, but since they are not inherited they cannot be considered parts of a biological development.

The psycho-physical mechanism of man is biological and innate and constitutes man's equipment for the production of cultures. Anthropology holds that the mechanism is general in so far as it is not limited to any particular culture, and that it enables the individual to practise any culture he may meet, tho not necessarily to equal degrees.

When we come to consider the biological theory of evolution we find that it applies to the psycho-physical mechanism but not to culture. For cultures we must have another point of view or theory and this in America, at least, is the historical or cultural conception. This conception is in general that cultural traits are the results of invention, a mental process, and their development or evolution is to be taken as a historical and psychological problem.

The paper was briefly discussed by Dr. Folkmar, Dr. Swanton and Dr. Hough.

Wm. H. Babcock, *Secretary.*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 262d meeting was held in the Cosmos Club, December 11, 1912.

### REGULAR PROGRAM

Presidential address—*Some variations in Upper Cretaceous stratigraphy:* T. W. Stanton. This address appears in full in this Journal **3**: 55. 1913.

The twentieth annual meeting was then held.

The reports of the Secretaries and Treasurer were read and accepted.

The following officers were elected for the year 1913: President, F. L. Ransome; first vice-president, David White, second vice-president, Arthur Keith; treasurer, Sidney Paige; secretaries, R. W. Richards, Frank L. Hess; Members-at-large-of-the-council, Wm. C. Alden, Adolph Knopf, C. E. Siebenthal, P. S. Smith, E. W. Shaw.

Dr. T. W. Stanton was nominated as candidate for the vice-presidency of the Washington Academy of Sciences to represent the Geological Society.

R. W. Richards, *Secretary.*

## THE PROCEEDINGS
### OF THE
## WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str., Berlin.

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VOL. III. No. 6.

MARCH 19, 1913.

# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES



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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. III, MARCH 19, 1913 No. 6

MINERALOGY.—*Calcium vanadates from Peru, Colorado and Utah.* W. F. Hillebrand, Bureau of Standards, Fred. E. Wright and H. E. Merwin, Geophysical Laboratory.

Among the vanadium minerals brought to this country from Minasragra, Peru, a number of years ago by Mr. Foster Hewett and briefly described by him were two, the one red the other orange, which analyses made by one of us (H) at the time showed to be hydrous calcium vanadates, probably hexavanadates.

Later, the senior author (H) received at different times from Messrs. T. F. V. Curran, A. G. McNaughton and R. H. McMillen, a red vanadium mineral from western Colorado, found in the Joe Dandy claim of the General Vanadium Company of America, Paradox Valley, Montrose County, about 12 miles from Naturita. This mineral, impregnating and filling cavities in a friable sandstone, closely resembles one of those from Peru.

Still more recently, samples of similar minerals from an unknown location in Paradox Valley and from Thompsons, in eastern Utah, were shown us by Mr. Frank L. Hess of the U. S. Geological Survey. Optical evidence proves that the one from Paradox Valley is the same as the red vanadate from Peru. The other, from Thompsons, Utah, as also the mineral from the Joe Dandy claim, differs in habit and also optically in some respects from the Peruvian mineral, tho chemically there is qualitative if not quantitative similarity.

The object of this note is to secure our right to study further and to name these minerals. An important feature of work still

to be done is the determination of the condition of the water—a tedious task—and the quantitative analysis of the mineral from Utah, hence it may be some time before we shall feel warranted in presenting our completed work. It will be better to describe all the minerals in one comprehensive paper, than to publish now incomplete details to be supplemented later.

Besides the red calcium vanadates we received from Messrs. McNaughton and McMillen a black friable sandstone, also from the Joe Dandy claim. It is not carbonaceous as one might suspect, but the black color is due to a vanadium mineral occurring in indistinct prisms (whether this is a calcium compound or not is as yet undetermined). It is somewhat doubtful if chemical study will reveal its exact composition, for other vanadium compounds are present with the black one, as is indicated by the existence of vanadium in three states of oxidation, corresponding to $V_2O_5$, $V_2O_4$ and $V_2O_3$. The greater part of the vanadium is in the $V_2O_4$ state, and to this the color of the rock seems to be due. In the course of time the specimens have taken on a greenish cast, but on freshly broken surfaces the color is still black.

It is much to be desired, both from scientific and commercial standpoints, that a careful geological exploration of the uranium-vanadium bearing areas of western Colorado and Eastern Utah be undertaken at an early date. These areas are being continually extended as new discoveries are made.

BOTANY.—*A new generic name for the sapote.* O. F. Cook, Bureau of Plant Industry.

Much confusion has attended the application of generic names to two important tropical fruit trees, the sapote and the sapodilla, the latter being the source of the chicle gum of commerce. Additional facts that tend to simplify these nomenclatorial complications have come to light during a recent review of the subject. The final result is to show that the generic name Achras belongs definitely to the sapodilla tree, and that a new generic name is required for the sapote. The reasons of these conclusions may be summarized as follows:

The Linnaean name Achras is a direct substitute for Plumier's genus Sapota. It was based by Linnaeus in his *Genera Plantarum* on Plumier's figures of an oval-fruited form of the sapodilla. The first binomial use of Achras in the first edition of the *Species Plantarum* is also typified by a reference to Plumier, so that there is no alternative to *Achras zapota* Linnaeus as the name of the sapodilla.. In the second edition of the *Species Plantarum* Linnaeus made the mistake of supposing that Plumier's oval fruit was a sapote, and the erroneous synonomy of this work has misled many later authors.

The retention of Plumier's name Sapota in Miller's *Gardener's Dictionary* (7 Ed., 1759) does not justify a revival of this name, since Miller followed Plumier in basing the genus on the sapodilla, tho the sapote was included as a second species. Some writers might consider this a reason for transferring the name to the sapote, but if such changes in the applications of pre-Linnaean names are to be permitted no advantage of stability is gained by accepting the substitutions made by Linnaeus. Tho such cases have not been the subject of direct nomenclatorial legislation, they are covered by implication under the rule that the substitution of a new generic name does not change the type of a genus. This seems to preclude the idea that the type can be changed informally, merely by referring other species to the genus. In other words, the use of a generic name for species that are not congeneric with the original type should not be allowed to change the application of the name. This is also partially recognized under another rule that provides for the selection of types of genera adopted from nonbinomial literature from those of the original species that receive names in the first binomial publication. The effect of this provision is to allow Linnaeus to change the applications of names as well as to substitute new names, so that all of the genera of Linnaeus' *Genera Plantarum* can be typified from the species placed under them in the *Species Plantarum*. But to extend this freedom to other authors who reverted, often quite casually, to the pre-Linnaean generic names, is to lose the practical advantages of the method of types. The recognition of a pre-Linnaean genus by a post-Linnaean author, tho it may

be supposed to revive the name under the binomial system, should not affect the application of the name.

The earliest binomial name applied to the sapote seems to have been Jacquin's *Sideroxylum sapota.*[1] The descriptive phrase accompanying this name refers to the compound calyx or involucre which is a peculiarity of the sapote, and there is also a citation of Sloane's plate of "The Mammee Sapota tree" of Jamaica. Jacquin's species was adopted by Linnaeus in the second edition of the *Species Plantarum*, but Jacquin's specific name would have become a homonym if transferred to the genus Achras and was replaced by *Achras mammosa* Linnaeus.[2]

Neither Sideroxylum nor Lucuma is available as a generic name for the sapote, both being based on species that are no longer treated as congeneric with this tree. The name Vitellaria, borrowed from Gaertner and applied to the sapote by Radlkofer, has been rejected by later writers and remains a hyponym, not having been associated with an identifiable generic type. Two other generic names, Calospermum and Calocarpum, proposed for the sapote by Pierre, prove to be homonyms.

A new generic name *Achradelpha* is accordingly proposed, with *Achradelpha mammosa* (Linnaeus) as the type species.

A more extended statement of the case, with discussions of some of the nomenclatorial principles involved, has been offered for publication in Contributions from the U. S. National Herbarium.

BACTERIOLOGY.—*The destruction of bacteria in milk by ultraviolet rays.*[3] S. Henry Ayers, and W. T. Johnson, Jr. Dairy Division, Bureau of Animal Industry. Communicated by Karl F. Kellerman.

During the past few years much attention has been given to the bactericidal action of ultraviolet rays. Numerous investigators have found that the ultraviolet rays of short wave length,

[1] Enumeratio pl. Ins. Carib. 1760.
[2] Species Plantarum, 2 ed. 1: 469. 1762.
[3] The complete data obtained in this work will be published as a bulletin of the Bureau of Animal Industry.

from 3000 to 2000 Angstrom units possessed a powerful bactericidal power and have endeavored to make a practical use of this fact. Water when clear has been successfully treated by the ultraviolet rays but when applied to milk the attempts to obtain a sterile product have not been so successful.

The object of the present work has been to determine if it is possible to sterilize milk by the ultraviolet rays and also how practicable the process would be.

In these experiments milk was exposed over two drums revolving in troughs in such a manner that milk was picked up from a trough in a thin layer by one drum, then taken off by a scraper and conveyed to a second tank where it was picked up by the second drum. After going over the second drum, the milk was collected by a second scraper which conveyed it to a sterile flask.

This apparatus enabled us to obtain layers of milk of different thicknesses by rotating the drums at various rates of speed which also, of course, varied the length of exposure.

The ultraviolet rays were generated by a quartz mercury vapor lamp operating on a 220 volt direct current circuit taking 3.5 amperes. The light tube of the lamp was at a distance of four inches above the surface of the drums. In general, it may be said, that the thickness of the layer of milk exposed averaged about 0.1 mm. The length of exposure over the two drums was about two seconds, when the drums were making 20 to 24 R.P.M. and about one second at 50 to 56 R.P.M.

| CONTROL MILK | EXPOSED MILK | |
|---|---|---|
| | Drums making 20-24 R.P.M. | Drums making 50-56 R.P.M. |
| *Bacteria per cc.* | *Bacteria per cc.* | *Bacteria per cc.* |
| 20,000 | 5 | 1,300 |
| 26,400 | 370 | 11,200 |
| 12,400,000 | 9,900 | 1,130,000 |
| 15,200,000 | 11,000 | 614,000 |
| 6,800 | 490 | 2,290 |
| 10,200,000 | 38,000 | 795,000 |
| 79,000 | 1,070 | 24,000 |
| 1,120,000 | 2,090 | |
| 1,660,000 | 3,700 | |

When milk was exposed in this apparatus, very satisfactory bacterial reductions were obtained as shown in the above table.

Thruout the experiments the temperature of the milk during exposure never was over 30°C. (86°F). Consequently high temperature played no part in the destruction of the bacteria.

Numerous experiments were performed to determine the action of the rays on vegetative cells and spores and to study numerous conditions which affect the power of the rays. A few experiments were also made to determine the possibility of sterilizing milk bottles by the rays. The results can be best presented in the form of a summary as follows:

1. When milk was exposed in thin layers to ultraviolet rays there was a marked reduction in the bacterial content.

2. The action of the rays was entirely independent of the action of heat since the temperature of the exposed milk was never over 30°C. (86°F.)

3. The most satisfactory method of exposure was over two revolving drums the tops of which were at a distance of 4 inches below the light tube of the lamp.

4. The two factors of greatest importance in the successful application of the rays were the thickness of the layer and the length of exposure. A thin layer allows a more complete penetration of the rays and the longer the exposure the more chance they have to act.

5. Ultraviolet rays exerted a greater bactericidal action on vegetative cells in milk than on spores when exposed under the same conditions.

6. No greater action of the rays on bacteria was observed when the bacteria were weakened by pasteurization immediately preceding the exposure.

7. From the study of two samples of milk exposed to ultraviolet rays it was apparent that the rays did not exert any specific bactericidal power on any particular group of bacteria in the milk. As stated before, however, there was a difference in the action of the rays on bacteria in the vegetative and spore state.

8. Under similar conditions of exposure there seemed to be somewhat less bacterial reduction in a 15 per cent cream than in

milk. This was probably due to the fact that the cream when picked up by the revolving drums was in a thicker layer than was the milk.

9. When milk was exposed under conditions suitable for a satisfactory reduction of the bacteria by the ultraviolet rays there was also produced an abnormal, disagreeable flavor. This flavor would render the milk unsaleable.

10. A large percentage of the bacteria in normally dirty and artificially infected milk bottles were destroyed by exposure to the rays. The best results were obtained when the bottles were exposed directly under the lamp, the top of the bottle being about 4 inches from the lamp tube. When bottles were exposed on one side of the lamp and not directly under it, poor results were obtained. It was not possible to completely sterilize the bottles even after a ten minutes' exposure.

## CONCLUSIONS

The experiments indicate that with quartz mercury vapor lamps of the present power and construction it would not be possible to completely sterilize milk by the ultraviolet rays.

It might be possible to obtain bacterial reductions as great as by pasteurization, even on a commercial scale, by the use of large, revolving drums and a number of lamps. However, in milk so treated there would be no assurance of the complete destruction of pathogenic organisms since the rays do not seem to exert any selective destructive action on vegetative cells. Of course, since pathogenic organisms might be assumed to be present in a small number in proportion to the total bacteria in milk, if 99.9 per cent of the organisms present were destroyed, it might be assumed that that the pathogenic bacteria would be destroyed. This process, however, would not afford the same security as does proper pasteurization. Then, again, it would be difficult on a commercial scale to control constantly the factors which influence the bactericidal action of the rays. Aside from these points the disagreeable flavor imparted to the milk by exposure to the rays renders the process impracticable on a commercial scale.

It is also doubtful if the lamps could be made to compete successfully with the present method of steaming milk bottles in order to partially sterilize them.

In conclusion, it must be stated that we have not intended to make this work an exhaustive study of the application of the bactericidal power of the ultraviolet rays. It is therefore possible that better results may be obtained in the future by use of more powerful lamps and different methods of exposing the milk.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

OCEANOGRAPHY.—*A study of the salinity of the surface water in the North Pacific Ocean and in the adjacent enclosed Seas.* AUSTIN HOBART CLARK. Smithsonian Miscellaneous Collections, **60**: No. 13, 1–13. 1912.

The complete salinity records of the *Albatross* cruise of 1906, corrected, are here given. The original observations were made by the author. A short preliminary account of the seasonal variation in salinity on the California coast, and of the conditions in the Bering Sea, as worked out from the *Albatross* records, is included.

In addition there is a short sketch of the surface variations in salinity and of the surface currents, mostly taken from the works of Vice-Admiral Makaroff. A. H. C.

PHYSICAL CHEMISTRY.—*On the effect of high pressures on the physical and chemical behavior of solid substances.* JOHN JOHNSTON and L. H. ADAMS, of the Geophysical Laboratory. American Journal of Science (4), **35**: 205–254. 1913.

This paper is an endeavor to review and to define the present status of our knowledge of the effect of high pressures on the behavior of solids, to reconcile some of the conflicting statements on the subject to be found in the literature, and to indicate the conclusions which may justifiably be drawn from the available evidence, especially with regard to their application to the discussion of geological phenomena. Some of this confusion results from the employment of indefensible criteria in ascertaining the character and magnitude of the change produced by pressure, as, for example, in determining the effect of pressure in promoting chemical reaction between solids, but in the main it is due to failure to take into account the fact that the effects produced depend upon the character, or mode of action, of the compression. The effects are different,

according as we are dealing with pressure uniform in all directions (true hydrostatic pressure) or with a mode of compression which does not satisfy this condition, in other words, the effects vary—as indeed is almost obvious—according as the solid retains its original form or undergoes deformation.

Uniform pressure has a comparatively slight effect on the melting point, it usually raises it, and by an amount, which in the systems hitherto investigated, is seldom greater than 10°, and never greater than 30°, per 1000 atmospheres. Its effect on solubility is slight, and for practical purposes negligible as compared with the influence of temperature upon solubility. Uniform pressure tends to further those reactions which are accompanied by a decrease of volume; but it by no means follows that it will cause these (or other) reactions to occur, for whether a reaction takes place or not is determined by its velocity under the particular conditions, and such evidence as there is tends to show that reaction velocity is not much affected by uniform pressure.

The effects of *non-uniform* pressure greatly outweigh those of uniform pressure. It *always* lowers the melting-point and raises the solubility, and by amounts which are many times greater than the corresponding changes with uniform pressure. If we make the plausible assumption that permanent deformation of a crystalline aggregate is conditioned by a real local melting (of those parts, which at any moment bear the brunt of the load), we find the amount of pressure required to cause melting at ordinary temperature to be within the bounds of probability. Such we believe to be the efficient cause in producing most of the phenomena recorded as occurring when solid systems were submitted to compression. This view, while it coordinates satisfactorily the whole of the experimental work hitherto done, conflicts with none of the available direct evidence.

It follows therefore that we can determine the effect of pressure on a solid system only if we can define the character of the compression (with reference to its approach to uniformity or otherwise) as well as its magnitude, and even then, only when the requisite thermal and other data, characteristic of the system, are available. J. J. and L. H. A.

ENGINEERING.—*The testing and properties of textile materials.* Bueau of Standards Circular 41, 1913.

The scope of textile testing which the Bureau of Standards is now prepared to undertake is summarized below.

1. Determinations upon raw and unspun fibers: (a) identity of fiber,

(b) approximate length; (c) moisture content and "regain"; (d) quantity of oil, grease and foreign substances contained; (e) percentage loss in scouring raw wool.

2. Determinations upon yarn, thread and twine: (a) length; (b) tensile strength and elasticity; (c) count or number; (d) twist; (e) percentage of loading, sizing and coloring material; (f) percentage fiber composition.

3. Determinations upon fabric: (a) weight; (b) tensile strength and elongation; (c) percentage fiber composition; (d) thread count; (e) yarn number of size; (f) folding endurance, (g) action of light on colors.

W. S. LEWIS.

ENGINEERING.—*Physical testing of cotton yarns.* W. S. LEWIS. Technological paper No. 19, Bureau of Standards. (In press.)

The investigation consisted in a study of single and two ply yarns as to variations in size, twist and tensile strength of yarns within cops, bobbins, skeins, etc., and also their behavior under various relative atmospheric humidities. W.S.L.

GEOGRAPHY.—*A study of biological paleogeography in its bearing on the origin of man in America.* AUSTIN H. CLARK. Science (N.S.), **35**: 669–670. 1912.

A short sketch of the ancient land connections between the Americas and other land masses, with the conclusion that man probably entered America over a broad land area connecting Alaska with northeastern Asia. A. H. C.

PALÆONTOLOGY.—*Restoration of the genus Eldonia, a genus of free swimming Holothurians from the Middle Cambrian.* AUSTIN H. CLARK. Zoologischer Anzeiger, **39**: Nr 25/26: S. 723–725. 1912.

A figure of a restoration of the curious holothurian described by Walcott as *Eldonia ludwigi* is given, together with a description of the animal.

The figure is a composite from all the figures published in the original paper. A. H. C.

BOTANY.—*A synopsis of the red firs.* WILLIAM H. LAMB. Proceedings of the Society of American Foresters, **7**: No. 2. 1912.

This is a discussion of the distinguishing characteristics of noble fir (*Abies nobilis* Lindl.), red fir (*Abies magnifica* Murr.), and Shasta fir (*Abies shastensis* Lem.). Much confusion exists as to the distribution

of these species in California and Oregon and especially in the region of the Klamath National Forest, where noble fir of the north is associated with red fir and Shasta fir of the south. To facilitate correct reports of the occurrence of the red firs, the conspicuous characters by which they may be most conveniently recognized are set forth with keys, photographs of typical cones, and drawings of leaf sections and of cone scales with bracts. W. H. L.

ZOOLOGY.—*Descriptions of eleven new crinoids belonging to the families Calometridae and Thalassometridae discovered by the* Siboga *in the, Dutch East Indies.* AUSTIN H. CLARK. Zoologischer Anzeiger, **39**: Nr. 11/12: S. 420–428. 1912.

Short preliminary diagnoses are here given of new species in these two families found by the *Siboga* . A. H. C.

ZOOLOGY.—*Seventeen new East Indian crinoids belonging to the families Comasteridae and Zygometridae.* AUSTIN H. CLARK. Proceedings of the Biological Society of Washington, **25**: 17–28. 1912.

Short preliminary diagnoses are herein given of seventeen new species of Comasteridae and Zygometridae discovered by the *Soboga* in the Dutch East Indies. A. H. C.

ZOOLOGY.—*Naumachocrinus, a new genus belonging to the crinoid family Phrynocrinidae.* AUSTIN H. CLARK. Proceedings of the U. S. National Museum, **42**: 195–197. 1912.

The genus Naumachocrinus, herein described, is closely related to the genus Phrynocrinus, heretofore the only known genus of the family Phrynocrinidae.

Naumachocrinus is from the Hawaiian Islands, and is the first stalked crinoid to be reported from that region, Phrynocrinus is from southern Japan, where it was discovered by the author in 1906. A. H. C.

ZOOLOGY.—*Six new East Indian crinoids belonging to the family Charitometridae.* AUSTIN H. CLARK. Proceedings of the Biological Society of Washington, **25**: 77–84. 1912.

Short preliminary diagnoses are herein given of six new species of Charitometridae discovered by the *Siboga* in the Dutch East Indies.
A. H. C.

ZOOLOGY.—*Notes sur les crinoïdes actuels du muséum d'histoire naturelle de Paris.* AUSTIN H. CLARK. Bulletin du Muséum d'Histoire Naturelle de Paris, No. 4, 1911: 243–260. 1911.

A complete list of the crinoids in the collection of the Paris museum, with redescriptions of the types of Lamarck and of Müller, detailed descriptions of the more interesting specimens other than types, and a detailed historical introduction.

The work upon these specimens was done in Paris. A. H. C.

ZOOLOGY.—*Die Fauna Südwest-Australiens: Crinoidea.* AUSTIN HOBART CLARK. Ergebnisse der Hamburger südwest-australischen Forschungsreise 1905, Bd. 3, Lief. 13, S. 435–467. 1911.

This paper is based upon the collection of Western Australian crinoids, principally from Shark Bay, made by Drs. Michaelsen and Hartmeyer while on the Hamburg West Australian Expedition. It is a monographic account of the crinoids of the western portion of Australia, including an historical introduction and a detailed discussion of the distribution. A. H. C.

ZOOLOGY.—*The recent crinoids of Australia.* AUSTIN HOBART CLARK. Memoir IV, Australian Museum, Sydney, New South Wales. Scientific results of the trawling expedition of H.M.C.S. *Thetis* off the coast of New South Wales, in February and March, 1898. Part 15, pp. 705–804. 1911.

This is a monographic account of the recent crinoids of Australia, based primarily upon the collections in the Australian museum at Sydney. It is prefaced by an historical introduction, and concluded by a complete bibliography. In its preparation the author visited all of the museums of Europe in which Australian crinoids are known to be preserved, and examined all the types of Australian species.

A. H. C.

ZOOLOGY.—*The crinoids of the Indian Ocean.* AUSTIN HOBART CLARK, B.A., F.R.G.S. Echinoderma of the Indian Museum, Part VII, Crinoidea, pp. i-iii, 1–325, 61 figures in the text, 4to. 1912.

A monographic account of the crinoids of India and the East Indies. In the introduction is given an historical sketch of the development of the study of the Indian crinoids, with a discussion of their distribution, ecology, etc., a complete bibliography is appended.

The synonymy and habitat of over 400 species are included, many of which are new. A. H. C.

ZOOLOGY.—*A revision of the American species of Peripatus.* AUSTIN HOBART CLARK. Proceedings of the Biological Society of Washington, **26**: 15–20. 1913.

The American species belonging to the family Peripatidae are distributed in the following genera: *Oroperipatus* Cockerell, *Peripatus* Guilding (with the subgenera *Plicatoperipatus*, nov., *Macroperipatus*, nov., *Peripatus*, *sensu stricto*, and *Epiperipatus*, nov.).

The American species belonging to the Peripatopsidae is considered as representing a distinct genus, which is recognized under the name of *Metaperipatus*, nov.

The family Peripatidae is divided into two subfamilies, Peripatinae, including *Mesoperipatus* (a central African type), *Oroperipatus* and *Peripatus* (with the included subgenera), and Eoperipatinae, nov., including the East Indian genus *Eoperipatus*. A. H. C.

ZOOLOGY.—*Notes on American species of Peripatus, with a list of known forms.* AUSTIN HOBART CLARK. Smithsonian Miscellaneous Collections, **60**: No. 17, 1–5. 1913.

*Peripatus* (*Peripatus*) *juanensis* Bouvier is recorded from the island of Vieques near Porto Rico, and *Peripatus* (*Macroperipatus*) *geayi* Bouvier is recorded from La Chorrera, Panama. In an appendix is given a list of all the American species of the group, with the ascertained range of each. A. H. C.

ZOOLOGY.—*On a small collection of recent crinoids from the Indian Ocean.* AUSTIN H. CLARK. Records of the Indian Museum, **7**: Part 3, No. 26, 267–271. 1912.

The collection herein described was received too late to be included in the monograph of the crinoids of India by the same author, and so an account of it was published as a supplementary paper. A. H. C.

ZOOLOGY.—*Preliminary descriptions of eleven new crinoids belonging to the families Himerometridae, Mariametridae and Colobometridae, discovered by the* Siboga *in the Dutch East Indies.* AUSTIN H. CLARK. Annals and Magazine of Natural History, (8) **10**: 31–41. 1912.

Short preliminary diagnoses are here given of new species in these three families found by the *Siboga*. A. H. C.

ZOOLOGY.—*Das relative Alter der rezenter Seelilienfaunen.* A. H. Clark. Naturwissenschaftliche Rundschau, J. G. 27, Nr. 15, S. 191–192. 1912.

An attempt is herein made to ascertain the comparative age of two faunas by internal characters. A. H. C.

ZOOLOGY.—*The crinoids of the Solomon Islands.* A. H. Clark. Records of the Australian Museum, **9**: 81–86. 1912.

A monographic account, with a bibliography, of the crinoids known from the Solomon Islands, based upon a collection from Ugi belonging to the Australian Museum of Sydney, New South Wales. A. H. C.

ZOOLOGY.—*The crinoids of the Natural History Museum at Hamburg.* Austin H. Clark. Smithsonian Miscellaneous Collection, **60**: No. 10, 1–33. 1912.

A complete list of the crinoids in the collection of the Naturhistorisches Museum at Hamburg, with redescriptions of types, detailed descriptions of the more interesting specimens other than types, an historical account of the collection, and a bibliography of the works based wholly or in part upon it.

Part of the collection was sent to Washington for study and comparison with material in the U. S. National Museum, but the greater portion was examined in Hamburg. A. H. C.

ZOOLOGY.—*The crinoids of the museum für Naturkunde, Berlin.* Austin Hobart Clark. Proceedings of the U. S. National Museum, **43**: 381–410. 1912.

A complete list of the crinoids in the collection of the Museum für Naturkunde, with detailed descriptions of the more interesting specimens with an historical account of the collection and a bibliography of the works based wholly or in part upon it.

There are also given lists of the type specimens, with the references to the original descriptions, of the species other than types mentioned in the literature, with the references, and of the specimens donated by this museum to the U. S. National Museum.

Most of the collection was sent to Washington for study, but the author examined the small remaining portion in Berlin. A. H. C.

ICHTHYOLOGY.—*Alaska fisheries and fur industries in 1911.* BARTON W. EVERMANN. Bureau of Fisheries Document No. 766, pp. 100. Issued December 16, 1912.

The Alaska Fisheries Service, which for the past two years has included administration of the Alaska fur resources also, is reported upon for the calendar year 1911 under the four departments of general administration, statistics, fish culture, and fur-seal service. The salmon fishery grounds, packing establishments and hatcheries were inspected as usual, and violations of law were duly reported and dealt with. The fisheries as a whole were found to have yielded 177,572,873 pounds of products, worth $16,863,728. The furs of all kinds shipped out of the territory had a value of $802,750, of which $432,231 was the value of sealskins.

From the standpoint of science the most important work was the continuation of observations in Nushagak Bay and Wood River, where the salmon runs are being counted yearly for the purpose of developing, thru the knowledge thus obtained, a satisfactory code of fishery regulations. The red salmon run was found to have decreased 30 per cent in the three years since 1908, but interpretation of this decrease depends, of course, upon the solution of now undetermined questions in the life history of the salmon. Among the most practical questions still unanswered are:

1. Do all species of salmon regularly return to the home stream, i.e., the waters where hatched, or are they diverted at any time by adverse winds, food conditions, etc.?

2. May the run in a stream be built up by closing the stream to fishing, and if so to what extent?

3. What is the normal age of each species and what period is spent in fresh water?

4. What percentage of fry under normal conditions is produced from eggs deposited naturally?

5. Are any disadvantages suffered by fish artificially hatched?

Somewhat inconclusive evidence confirming the parent-stream theory has resulted from experiments in marking young salmon, and indications are negative as to the utility of closing streams to fishing. The third of the above questions alone seems to be approaching solution, by means of examination of scales of the fish. A rather hasty examination of scales of a small number of Nushagak salmon in 1911 leads to the conclusion that the greater number of adults return at five years of age instead of four as has been believed on the basis of the Fraser River runs.

ETHEL M. SMITH.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 263rd meeting was held in the Cosmos Club, January 8, 1913, and the formal communications were presented:

*The bearing of Pre-Cambrian structure on the origin of the Homestake ore body:* SIDNEY PAIGE. It is suggested that the main Homestake ore body owes its origin to the presence of a strong fault and the subsequent mineralization of a calcareous series. Geologic work has proved the existence of the calcareous series on the surface and in the mine and structural considerations demand the fault. The form of the ore body is that which would be taken if a folded sedimentary series were cut by a fault and replaced by solutions rising along the fault. The particular form which observed facts would require of such a calcareous series as is present agrees with the form of the ore body as determined by mining. Microscopic examination of ores and wall rocks, as far as carried on, support this hypothesis.

*A recent discovery of dinosaurs in the Tertiary:* W. T. LEE. Ceratopsian bones were found during the summer of 1912, nine miles east of Colorado Springs, Colorado, in sec. 3, T. 14 S., R. 65 W., about 500 feet above the base of the Dawson arkose (the lower part of the Monument Creek formation of former writers). Dinosaurs were found at a locality that had previously yielded a bone of a Tertiary mammal and a number of Eocene plants which, according to Knowlton, belong in the Denver flora. On the evidence of the plant remains the beds containing the dinosaur bones are correlated with the oldest Tertiary (Raton formation) of the Raton Mesa region in southern Colorado and northern New Mexico, and with the Wilcox-Eocene formation of the Gulf region.

It has long been known that the beds now called Dawson arkose lie with conspicuous unconformity on older rocks that range in age from Laramie to pre-Cambrian, and this unconformity, together with the presence in the beds above it of a Tertiary mammal and of Eocene plants, is thought sufficient to establish the Tertiary age of the Dawson arkose; and inasmuch as the Ceratopsian bones were found in the same beds it is concluded that some of the dinosaurs existed in early Tertiary time.

*A paleobotanical study of the coal-bearing rocks of the Raton Mesa region of Colorado and New Mexico:* F. H. KNOWLTON. The coal-bearing section in the Raton Mesa region was first (1867–1878) considered by Lesquereux, on paleobotanical evidence, as referable to the Tertiary and similar in position to the Lignitic, or Eolignitic, of Mississippi, but later

(about 1883 to 1907) it came, without additional study of the plants, to be regarded as Laramie on the basis of its supposed similarity to the Laramie of the Denver Basin. The renewal of interest in the region began in 1907, at which time W. T. Lee detected the presence of a wide-spread unconformity in the midst of this supposedly continuous Cretaceous section. To the coal-bearing beds below the unconformity the name Vermejo formation has been given, while those above are known as the Raton formation. The present paleobotanical study was undertaken to give such answers as it might as to (1) the distinctness of these formations and (2) as to their age. The results of this study are satisfactory and seemingly conclusive.

The fossil flora of the Raton Mesa region comprises 257 forms of which number 106 are found in the Vermejo formation and 151 in the Raton formation. As only 4 species have been found to cross the line of the unconformity we have the answer to the first question, namely as to the distinctness of the two formations.

The Vermejo flora is shown to have no appreciable relation with the Laramie of the Denver Basin, since there is but one species in common. Its close affinity (identity of over 90 per cent of the species having an outside distribution) is with the Mesaverde, and the conclusion is reached that Vermejo formation is Montana in age and in the approximate position of the Mesaverde.

The Raton flora has 5 species in common with the Laramie of the Denver Basin, 4 with the Arapahoe formation, between 30 and 40 with the Denver, and over 30 with the Wilcox formation. As the Wilcox has intercalated layers of marine Eocene invertebrates, and itself rests on the marine Eocene Midway formation, the conclusion is reached that the Raton formation is in approximately the same stratigraphic position, and is also Eocene in age. As the Denver formation occupies approximately the same position as the Raton formation, it may be taken as additional proof that the Denver is likewise of Eocene age. This latter result, however, is merely a confirmation of the original contention of Cross, who named and described the Denver formation.

The broader application of these results to the stratigraphic position of the ceratopsian dinosaurs elsewhere is obvious.

FRANK L. HESS, *Secretary*.

## THE BIOLOGICAL SOCIETY OF WASHINGTON

The 33rd annual meeting was held in the hall of the Cosmos Club, December 14, 1912, with Vice-President W. P. Hay in the chair. Reports of officers for the year 1912 were received and the annual election of officers took place. The election resulted as follows: *President*, E. W. NELSON; *Vice-Presidents*, J. N. ROSE, PAUL BARTSCH, W. P. HAY, A. D. HOPKINS; *Recording Secretary*, D. E. LANTZ; *Corresponding Secretary*, N. HOLLISTER; *Members of Council*, HUGH M. SMITH, VERNON BAILEY, WM. PALMER, A. B. BAKER, and A. K. FISHER.

The 505th regular meeting was held January 11, 1913, with President E. W. Nelson in the chair and 54 persons present. The chairman appointed standing committees on Publications and Communications for the year.

C. V. PIPER exhibited a vase made of wood and covered with a thin veneer of "silk-wood." This veneer is cut from one of the large Polyporus fungi and takes a beautiful polish.

A. S. HITCHCOCK and E. W. NELSON each reported his recent return from a successful collecting trip, the former having collected grasses in Jamaica, Trinidad, and Tobago, while the latter had secured birds and mammals in Arizona.

The regular program consisted of the communications:

*The rediscovery of Œnothera grandiflora:* S. M. TRACY. The speaker gave an account of two trips made by him to the locality of Bartram's original discovery of this species. (1776). The locality is near Dixie Landing, Alabama, and the flower described by Bartram was found abundant over a limited area. A second visit was made last year in company with Dr. Hugo de Vries.

*The problem of the identity of Œnothera Lamarckiana:* H. H. BARTLETT. The speaker gave a history of various cultivated strains of plants of this species and its hybrids. He predicted that its original habitat and identity—as yet unknown—would eventually be discovered, probably in America south of the United States and on the Pacific Slope.

*Sawflies and their relation to forestry:* S. A. ROHWER. These very destructive insects were classed as defoliators and wood borers, and many instances of serious damage by them to growing timber were given. The paper was illustrated by numerous lantern slides showing various species of sawflies—adults, pupae, and larvae—and also illustrations of damaged timber.

The 506th regular meeting was held January 25, 1913, with the President in the chair and 47 persons present.

The following resolution relating to Zoological Nomenclature was presented to the Society with the endorsement of the Council and adopted unanimously:

*Whereas* certain zoologists have gone on record as favoring (1) A permanent and increasing list of exceptions to the law of priority; (2) A return to the principle of elimination regardless of the generic types that have been designated under the rules, and (3) A rejection of the present unanimous vote rule that has obtained for so many years in the International Congress on Zoological Nomenclature,

*Therefore,* be it resolved by the Biological Society of Washington that we favor (1) The consistent application of the Law of Priority in all cases; (2) The acceptance of the first designation of a genotype, regardless of the method followed in designating it, and (3) The present unanimous vote rule as making for conservation and stability in nomenclature.

Under the heading Brief Notes, etc., PAUL BARTSCH exhibited a small Ographic camera, with a number of small pictures made with it and enlargements of the same. He spoke briefly of its convenience and adaptability to field uses.

Barton W. Evermann reported that a wireless message had just been received from Agent Lembkey at the Pribilof Islands in which it was stated that the reindeer herds on St. Paul and St. George had increased during the past year from 37 to 65 animals and that all are in excellent condition.

The regular program consisted of two communications:

*Notes on the biology of the common termites of the eastern United States:* Thomas E. Snyder. This paper was illustrated by many lantern slides and was discussed by E. A. Schwarz.

*The biting powers of ants:* W. L. McAtee. The speaker's personal observations as well as instances gathered from many sources were cited to show the powers of these small animals. Messrs. E. A. Schwarz, A. C. Weed, A. D. Hopkins and the author of the paper took part in the discussion which followed.

The 507th regular meeting was held February 8, with President Nelson in the chair and 57 persons present.

Prof. Burt G. Wilder gave an illustrated lecture on *The brain as a guide to the affinities of vertebrates,* basing his remarks primarily on the brain of the shark Pentanchus recently described by Smith and Radcliffe as the type of a new family. The speaker showed by means of diagrams the evolution of the selachian brain from the most primitive form found in Chlamydoselachus thru the other Notidani to the typical sharks; and announced his conclusion, from the evidence afforded by the brain, that Pentanchus is not a Notidanid. He did not venture, however, to say just what the systematic position of this shark may be until the vertebrae and intestines have been studied, although it is certainly not related to the Scylliorhinidæ, to which Regan (*Science,* July 19, 1912) assigns it on the theory that the single dorsal fin is an abnormality.

In the discussion which followed, H. M. Smith said that in assigning Pentanchus to the order of ancient sharks, partly on account of the single dorsal fin, he and Mr. Radcliffe had been aware of characters in which this shark differs from typical Diplospondyli, but that no other course seemed expedient at the time the preliminary description was published. The vertebrae, while not diplospondylous but modified cyclospondylous, are of a very primitive type, being only half the size of those in a scylliorhinid shark of the same length, with an extremely small centrum and a very large neural canal.

Theodore Gill discussed the subject at length, and agreed with Prof. Wilder in attaching great taxonomic importance to the brains in sharks and rays. He had concurred in the assignment of Pentanchus to the Notadini, and now regarded it as the type of a peculiar family whose affinities remain to be determined.

D. E. Lantz, *Recording Secretary.*

THE PROCEEDINGS

OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str.. Berlin.

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# JOURNAL

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# WASHINGTON ACADEMY OF SCIENCES

VOL. III, APRIL 4, 1913 No. 7

PHYSICS.—*The constants of spectral radiation of a uniformly heated enclosure.* W. W. COBLENTZ, Bureau of Standards.

In a previous communication to this Journal a general description was given of the work[1] which was completed prior to December, 1912. It was then proposed to observe several more sets of energy curves, at the highest operable temperatures with a vacuum furnace before publishing the exact numerical results. Owing to unavoidable delays in assembling all the apparatus, the intention of witholding all the data until the completion of this investigation has now been abandoned and in the present paper is given a brief summary of the most reliable data now at hand.

The temperature scale used in this investigation, for temperature above 1400°C is the optical scale, which is obtained by adding to the thermoelectric temperatures certain values,[2] which are the mean of several groups of thermocouples. In assembling the present data for publication it was observed that for temperatures above 1400°C there was an abrupt rise in the value of the constant $c$ which increased systematically to abnormally high values for temperatures taken above 1500°. It was therefore necessary to choose between the possibility that (1) this variation in $c$ at high temperature is owing to the failure of Planck's law at high temperatures or (2) that, for the particular thermocouples

[1] Coblentz, Jour. Wash. Acad. Sci., **3**: 10, 1913.
[2] Waidner and Burgess, Bull. Bur. Standards **3**: 205, 1907.

used in this research the aforementioned correct factors for reduction to the optical scale are too large.[3] The writer chose the latter conclusion and the results obtained at high and at low temperatures are now in agreement.

The systematic errors, which formerly caused the mean values of the various sets of observations to differ by 0.2 to 0.5 per cent, are now reduced to less than 0.2 per cent. They were caused by the presence of a disproportionate number of high temperature energy curves, in some sets of data, which contained the aforementioned corrections for reduction to the optical temperature scale. This modification of the correction for reduction of the thermoelectric temperatures to the optical scale has no effect upon the data obtained in 1912 owing to the fact that intentionally, (to save the thermocouple calibration; the difficulty with the scale correction was not forseen) no energy curves were observed at these high temperatures. The former unexplained disagreement between the sets of observations made in 1911 and those of 1912 is now reduced to an excellent agreement. This was to be expected for there was no apparent difference in the methods of operation other than the addition of a number of high-temperature, energy curves to the series of 1911, which required the optical scale corrections.

The series of 1911 is the most accurate as regards low humidity while the series of 1912 excel in having the most improved methods and the longest experience in the work. The results of the two years work are given in Table I. Each value of $c$ is the mean of the number of isothermal energy curves (94 in all) given in column 2, computed by equation (2) published in the previous communication to this Journal. The mean value is

$$c = 14456 \pm 4$$
$$A = 2911 \pm 1$$

In the complete paper it will be shown that the values obtained by Lummer and Pringsheim, if computed by the present methods

[3] In the complete paper it will be shown that, for these particular thermocouples, the mean value correction factors for reducing the thermocouple temperatures to the optical scale are too large by 5 to 7, depending, of course, upon the temperature above 1400°C.

would give a mean value of $c = 14465 \pm 40$ and that the values published by Paschen, if similarly corrected would give a mean value of $c = 14458 \pm 25$.

The most recent communication from Warburg[4] and his associates gives a mean value of $c = 14374 \pm 4$. The mean value of the four sets of investigations weighted as follows ($L$ and $P = 1$ $P = 3$, $W = 10$ and $C = 10$) gives a mean value of;

$$c = 14420 \text{ mikron deg.}$$
$$a = 2905 \text{ mikron deg.}$$

The mean value of the most recent work by Warburg and by the writer is $c = 14415$.

TABLE I

| SERIES | NUMBER OF ENERGY CURVES | MEAN VALUE $c$ | REMARKS |
|---|---|---|---|
| 1911 | | | |
| I | 26 | 14,469 | Unpainted Marquardt porcelain radiator. |
| 1912 | | | |
| I | 7 | 14,463 | Unpainted radiator as used in 1911. New optical adjustments. |
| II | 14 | 14,432 | Radiator painted with chromium oxide. |
| III | 7 | 14,466 | New unpainted Marquardt radiator. |
| IV | 9 | 14,446 | Radiator painted with the oxides of cobalt and chromium. |
| V | 14 | 14,476 | Radiator repainted; new optical adjustments. |
| VI | 8 | 14,461 | New thermocouples; radiator same as in preceding series. |
| VII | 9 | 14,436 | New watercooled shutter, No. 1, The rest of the apparatus is the same as for the preceding series. |

Mean value $c = 14,456 \pm 4$ (94 energy curves)
$A = 2911 \pm 1$

The value $c = 14420$ is a convenient one to use. The difference in the values obtained by Warburg and by the writer indicates an uncertainty of about 5° at 1750°C. It is rather remarkable

[4] Warburg—Leithaüser, Hupka, Müller, Sitzber, Akad, Wiss. Berlin I, p. 35. 1913.

that the older data (which were reduced by the present system of computation long before the inconsistencies among the various sets of the present observations were eliminated) are in close agreement with the present results.

PHYTOPATHOLOGY.—*Environmental influences in the pathology of Solanum tuberosum.*[1] W. A. ORTON, Bureau of Plant Industry.

The health and vigor of plants is largely dependent on their adaptation to their environment. Each species has its optimum requirements as to temperature, moisture, light and substratum, variations from which result in failure of the plant to reach a normal or maximum development and predispose it to disease.

Under certain environmental conditions, for example, the plant becomes more susceptible to the attacks of parasites, either because the germination and development of the parasite is favored or because the weakened host has lost its natural resistance. Another type of disease is not associated with any parasites, but comes from some perversion or loss of physiological functions, which seems also, in the last analysis, to be attributable to defects in the environment.

It is to be expected that the most favorable climate for any plant will be that of its nativity, to which it has become adapted in the course of its evolution. Certainly the students of crop plants should consider first the natural adaptations of their plant in the land of its origin, and next any modification that may have resulted from subsequent culture in other countries.

The native habitat of *Solanum tuberosum*, the progenitor of our potato, is believed to be in southern Chile, where it was found growing wild by the early explorers and where it still occurs. Darwin, in the *Voyage of the Beagle* describes his experiences on the Island of Chiloe, where "the wild potato grows . . . . in great abundance, on the sandy, shelly soil near the sea beach."

[1] Address of retiring President, Botanical Society of Washington, February 25, 1913.

De Condolle, after a critical study of the evidence, concludes that the potato is native in southern Chili and expresses doubt as to Peru and the other northern Andean countries, where it was in general cultivation by the natives at the time of the discovery and conquest by the Spaniards and where its present occurrence in a wild or semi-wild condition may be thru escape from the primitive Indian cultures.

That our potato may have come from a region where high altitudes give a temperate climate within the tropics is, however, not impossible, since other species of Solanum do occur thruout the Andean region and northward as far as Colorado, and may have given origin or contributed thru crossing to the potato which we cultivate today. There is great need for further taxonomic studies to throw light on this point. From the physiological standpoint, however, there can be no doubt that the potato originated in a region of low and uniform summer temperature, a fact of the greatest significance to agriculture in the United States, where different climatic conditions prevail.

It will be shown that in the Northern Hemisphere those regions are most successful in the cultivation of the potato where the temperatures during the growing period most nearly approach those of southern Chili, and that the climatic environment is the most important factor influencing the diseases of this crop.

The climate in the district where we believe the potato to be indigenous is marked by very uniformly cool summers and heavy winter rainfall. Valdivia has a mean annual temperature of 52.8°F. the maximum is 90°; and the minimum 30° (figs. 1 and 2); Puerto Montt and Ancud are similar. To the northward, as the climate becomes hotter and drier, the potato is more and more restricted to the higher elevations, where the climate is temperate and the summers cool and equable. The relative atmospheric humidity will be high in these cool regions. This is doubtless a more important point for the normal development of the potato than the absolute rainfall.

Of all countries where it has been introduced the potato perhaps yields best in Scotland, and here we find the summer nearly

as cool as in Chili, though the rainfall is less (figs. 1 and 2). Northern Germany is justly renowned for its potato harvests, which, in bushels per acre, are more than double those of the United States, and there also the growing period is long, cool and equable. The limiting factor is the rainfall, which is low, tho well distributed (Cf. Edinburg and Posen in figs. 1 and 2).

The July isotherm of 65°F. crosses North America not far from the northern border of the United States. Only in Aroostook County, Maine, and parts of northern New York have we develooped extensive potato culture north of this isotherm, which in

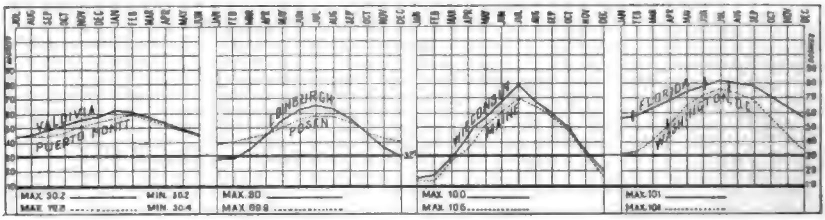


Fig. 1. Curves of mean monthly temperatures for Valdivia and Puerto Montt, in southern Chile, compared with Edinburgh, Scotland; Posen, Germany; Handcock, Wisconsin; Aroostook County, Maine; Federal Point, Florida, and Washington, D. C. Data from the first four were compiled from Hann's "Klimatographie;" the latter four from reports of the U. S. Weather Bureau.

Europe runs south of the principal potato districts of Great Britain and northern Germany. The isotherm of 70°F. (21°C.) for June, July and August nearly marks the southern boundary of successful main crop potato production in the United States. The climate of the greater part of the United States is therefore too hot for best results with this crop. As shown in figures 1 and 3, the production of potatoes in the South is a matter of early spring planting and summer harvesting, or of planting in late summer for autumn harvests. For the latter procedure a type of potato illustrated by the variety McCormick is well adapted in the region of Washington, D. C., a fact worthy of mention here for its significance in the problem of securing a heat resistant potato for southern districts. The summer heat of the United States is the limit-

ing factor in potato production. Only young plants can survive exposure to 90°F. for any extended priod, hence we find a tendency to plant late in the north in order that the time of tuber formation may come during the cooler weather of autumn.

It appears that most or all of our present varieties originated in northern districts, from parent stocks having low temperature requirements. To secure varieties capable of extending potato culture southward local breeding should be practised if stocks possessing the necessary physiological qualities can be found. Our great need is to discover a variety of *Solanum tuberosum*,

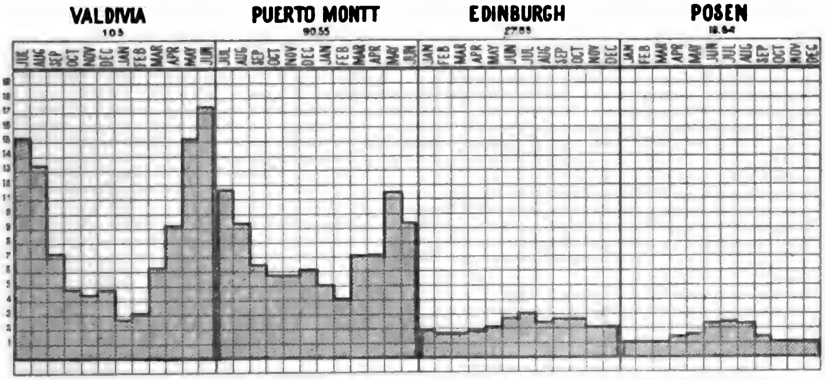


**Fig. 2. Chart showing average monthly rainfall for points in southern Chile as compared with Europe.**

or a species sufficiently related to hybridize with it, that is indigenous to a region of high temperature, and capable of transmitting to crosses with existing cultivated races a heat enduring quality derived thru better control of transpiration, or in other ways. It will be evident from a consideration of the south Chilean climate that the heat resistant factor cannot be found there. We must turn to more northern and warmer sections of South or Central America, a region that has been very inadequately explored to date, but where Mr. Wight of this Society is now engaged on this mission.

Turning now to the consideration of potato diseases, we shall find in the late blight, caused by the fungus *Phytophthora infestans*, an excellent illustration of the extent to which climatic environ-

ment influences disease. Late blight is limited by its requirements of abundant moisture and moderate temperature, hence it is most common in the Northeastern States, occasionally extending southward in early summer or autumn, never in midsummer. Hot or dry weather checks its spread. These well established facts strongly support the hypothesis that *Phytophthora infestans* is endemic in the native habitat of the potato. Our knowledge of the general principles of immunity in plants further suggests that there would be the place to seek strains of the host plant possessing a high resistance to this parasite.

In early blight, due to the fungus *Alternaria solani*, we find that higher temperatures than those best for the potato appear to promote infection. The range of greatest prevalence is well to the south of that for late blight.

Another instance of apparent geographical limitation of potato diseases is afforded by the wilts due to *Fusarium oxysporum* and *Verticillium albo-atrum* respectively. The Fusarium wilt is southern in its general range, being most prevalent in California, in the warmer irrigated valleys of the West and in the East Central States. Verticillium, on the other hand, occurs in the most northern districts from the Puget Sound to Maine. The two overlap in their distribution but have the general tendency stated.

Pathological conditions not due to parasites are even more conspicuously associated with attempts to grow the potato outside of its natural range. A heat and drought reaction common in the United States is that known as tipburn, where the leaves exposed to the hot sun and low relative humidity of midday curl and burn at the margins, indicating an excessive transpiration. This is seldom met with in Europe.

Premature ripening follows when potatoes bearing half-grown tubers are exposed to the midday heat of our Southern States. There is in addition to the tipburn a yellowing and early death of the foliage. Potatoes produced in these southern conditions lose their constitutional vigor and germinate later, with small weak sprouts and give a smaller yield than seed from northern sources. This constitutional defect is not cured by restoration to a northern environment.

There is another group of apparently physiological or inheritable potato diseases, of which "leaf roll" and "curly dwarf" are most important, which I bring into this discussion because they are probably deterioration phenomena connected in some way not yet fully understood with the effect of unfavorable environmental conditions.

The great losses that have been caused by these diseases both in Europe and America have caused much alarm and led to much investigation and discussion. The suggestion that our potato

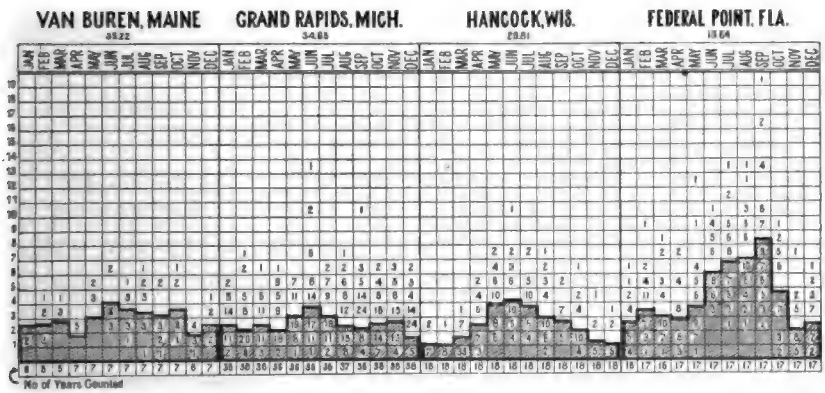


Fig. 3. Average monthly rainfall for four potato centers in the United States. Data from U. S. Weather Bureau. The heavy upper border of the shaded area shows the mean rainfall for the number of years indicated at the base of the column. The figures within the squares in the shaded area show the number of years within the period of record when the rainfall has been below the amount indicated. The corresponding figures in the white squares show the number of years during the period of record when the rainfall has exceeded the amount indicated.

varieties may suffer rapid deterioration thruout extensive districts and without discoverable cause is naturally provocative of uneasiness. While the nature and cause of "leaf roll" and related troubles is still largely a matter of speculation, the haze is partially cleared by the separation of this complex into at least five different troubles, three of which are attributable to known parasites.

As pointed out by the writer in December, 1911, in a paper before the American Phytopathological Society, the following diseases have been more or less confused by various observers:

1. Potato wilt due to *Fusarium oxysporum* (Schlecht.) Sm. & Sw., a disease widespread in the central and southern United States but not yet proved to exist in Europe.

2. Potato wilt due to *Verticillium albo-atrum*, a disease occurring in the northern United States, in Great Britain and northern Europe.

3. Potato rosette and other troubles caused by Rhizoctonia, especially prevalent in the western United States.

4. Leaf roll, an inheritable, probably non-parasitic disease prevalent in Europe and parts of America.

5. Curly dwarf, an inheritable, non-parasitic disease found both in Europe and America.

Leaf roll (Blattrollkrankheit) is a disease characterized by an upward rolling of the leaves, by a decreased yield of tubers and by transmission of the diseased condition thru tubers planted.

The rolling of the leaves is the most constant and conspicuous symptom of this disease. The leaflets curl or roll upward on their midrib, often assuming a nearly tubular shape, and giving the plant a staring appearance. This rolling is sometimes restricted to the upper leaves, while in other cases all or nearly all of the leaves on the plant exhibit it. This type of roll is distinct from the curly leaf condition but a very similar roll may be induced by other causes, such as wet soil, "black leg" and other diseases.

The color of the foliage changes with the advent of leaf roll, but these color symptoms vary greatly, from cases where the leaves assume an unhealthy, light green color to those marked by pronounced yellowish, reddish or purplish colors.

The time of onset is early as compared with Fusarium wilt. The effect on the plant is to check development. There is a lessening or cessation of growth. The duration of life of the plant, in some cases appears to be shortened by leaf roll, but in comparison with the rapid death of American potatoes attacked by Fusarium wilt the leaf roll is very slow in the action.

The endurance of the seed piece as a character of leaf roll is an interesting point frequently mentioned in the German literature, and is considered by Appel to be one of the symptoms of leaf roll. The effect of leaf roll on the tubers is strongly marked.

In general the yield is very much reduced. The diseased hills have numerous tubers very much smaller than normal so that the yield is only about half that of a healthy field. If one uses these potatoes again for seed, the greater part fail to develop, and an uneven stand is the result. The stronger tubers succeed in growing, but the stem remains weak, the leaves are from the beginning considerably rolled and more or less colored. Few or no tubers are found in such hills, so that a complete crop failure results. Stem end browning of tubers is no longer considered a reliable evidence of leaf roll.

The true leaf roll is inheritable. The tubers from diseased plants produce diseased progeny as a general rule. This affords a means of distinguishing from genuine leaf roll those temporary conditions which give rise to a similar appearance of the plants. It is now quite generally admitted that the presence of fungous mycelium is not a character of the leaf roll. The leaf roll diseased plants in America have been free from fungous infection.

The leaf roll disease of potatoes first came into the public eye in Europe in 1905 in Westphalia. In 1907 a more general outbreak occurred in Germany and much alarm was expressed. Its occurrence is certain in Germany, Austria-Hungary, Switzerland, the Netherlands, Denmark, Norway and Sweden, as well as in the United States.

Two developments of leaf roll in this country have been studied. One in a collection of seedlings grown by the Bureau of Plant Industry, the other a destructive outbreak in eastern Colorado and western Nebraska during 1911 and 1912, which was the cause of immense losses, the shipments from one district falling from an expected 7000 cars to 200 cars.

The seedling potatoes showed every degree of variation in plant characters, and in addition many showed distinct evidence of the diseased condition herein described as leaf roll. It is noteworthy that in neither field was there any trace of Fusarium wilt, nor of Verticillium wilt, "black leg" or "mosaic," altho the latter three were common in adjoining fields. The evidence indicates that leaf roll and curly leaf are manifestations of physiological weakness and associated with decline or loss of vigor of the strain.

The hypotheses as to the cause of leaf roll are numerous and varied. It has been argued by one that leaf roll results from the use of unripe tubers for seed; by another, that it is due to the employment of matured tubers; while a third believes that seed from prematurely ripened plants is a cause of leaf roll.

Hiltner is the leading advocate of the theory that the immature seedstock gives an abnormal growth. He limits this to those potatoes which are prematurely ripened by drouth or other untoward circumstances. Hiltner further holds that leaf roll may be the result of an overconcentration of salts as thru excessive applications of fertilizer, of unbalanced composition and applied at the wrong time.

The first appearance of leaf roll in Germany was on the variety Magnum Bonum and was considered as an evidence of varietal deterioration. It seems certain, however, that leaf roll is not a result of "running out" of varieties thru old age, for many strains originated recently are affected. Its occurrence in seedlings has been observed by several workers. An interesting suggestion is put forward by Hedlung that leaf roll is a pathological adaptative mutation, and further, that since acquired characters are not inherited the leaf roll character must be latent in normal potatoes.

The introduction of new and more vigorous varieties affords a hopeful means of ultimately controlling the situation.

Under the name "curly-dwarf" there is to be differentiated from the leaf roll a peculiar disorder known in Germany as "Kräuselkrankheit." This is characterized by a dwarfed development of the potato plant, accompanied by a pronounced curling and wrinkling of the foliage, which has been compared with Scotch Kale and with Savoy cabbage. The stem and its branches, the leaf petioles and even the midribs and veins of the leaves all tend to be shortened in many cases to a very marked extent, particularly in the upper nodes of the plant, so that the foliage is thickly clustered. The diminished growth of the leaf veins, in proportion to the parenchyma, results in a bullate, wrinkled leaf, often strongly curled downward. There seems also to be a tendency to form more secondary branches than normal, and as these

remain short and with curly leaves, the compactness of the plants is more striking.

The color of the foliage in curly-dwarf is typically normal green. The tuber yield is greatly curtailed. Severe cases have no tubers. In others, a few small potatoes are formed. The hereditary nature of the trouble is attested by the German authorities and has been observed by the writer.

In the United States curly-dwarf plays a larger role in the deterioration of our potatoes than in Europe. It must be regarded as a physiological disorder, which crops out in previously healthy stocks, under conditions not yet known to us. Once developed, it is apparently not possible to restore the vigor of the affected hills.

Examination of a variety or seedling collection shows that there are all grades of the condition above described from pronounced types of curly-dwarf to those approaching normal vigor. It will furthermore be apparent that this is a difference inherent in the varieties or strain under observation.

Both leaf roll and curly dwarf develop suddenly from hitherto healthy stocks and both are transmitted by planting tubers from diseased plants. That whole districts should be affected as in Westphalia in 1907 and in Colorado in 1911 indicates a physiological deterioration due to environmental relations, unless a parasite should be demonstrated, which has not yet been done.

The climatic charts presented show that there is a great deficiency of moisture in Germany and Colorado in comparison with Chili. Is it possible that under these conditions varieties of potatoes may lose their vigor and undergo physiological changes comparable with those already noted for southern grown seed?

That the leaf roll disease is being brought under control in Germany by the use of healthy seed potatoes from outside the affected districts supports these hypotheses and lends still more strength to the argument for potato breeding for a higher degree of climatic adaptation.

Altho nothing like the present outbreak of leaf roll has occurred during the last forty years, an examination of old literature shows that about 1770 and in subsequent years there were epi-

demics of "leaf curl" and "Kräuselkrankheit" in England and Germany respectively, the description of which are much like the troubles of today.[3] Are our potato varieties passing thru another period of decline in vigor?

## ZOOLOGY.—*Web-spinning fly larvae in Guatemalan caves.* O. F. Cook, Bureau of Plant Industry.

The limestone mountains of the Department of Alta Verapaz, in eastern Guatemala, abound in caves, most of them as yet quite unexplored. Ancient remains show that some of the caves were used for burial places in prehistoric times, which may account for the aversion of the present Indian population to entering this underground world. Two caves on the Trece Aguas coffee estate near Senahú were visited by the writer on March 30, 1906, to see whether they contained millipeds or other cave-dwelling arthropods.

In one of the caves, which was very dry, a few human teeth were found with small circular mounds of earth where ancient pottery vessels had crumbled, tho in some cases the rims remained. The other cave, which was entered by crawling thru a low narrow passage, partly filled with water, had also been used for burial purposes and one of the chambers showed a few rude designs traced in black, something after the manner of Mayan hieroglyphics. There were several large chambers, some of them with lofty roofs and extensive deposits of stalactites and stalagmites. The air was very damp owing to wet walls and dripping water. It was in one of the inner chambers of this cave, probably at least 100 yards from the entrance, that curious fringelike webs were noticed hanging from the roof. A sloping floor brought us up close to the webs, and the light of an acetylene lamp rendered the glistening threads very conspicuous against a background of complete darkness.

The general plan of these webs is entirely unlike that of any spider or other web-building arthropod of the upper world, and could be used only in caves or in very sheltered recesses of forests.

[3] Cf. Thos. Dickson, Memoirs Caledonian Hort. Soc., March 6, 1810.

The only familiar objects to which the webs can be compared are the rope signals that are hung near bridges and railroad tunnels to avoid accidents to train crews. The construction is simple but rather extensive, the webs being usually over a foot long and sometimes nearly 2 feet. Usually the same general direction is kept, along the roof of the cave, but sometimes there is a simple curve and return.

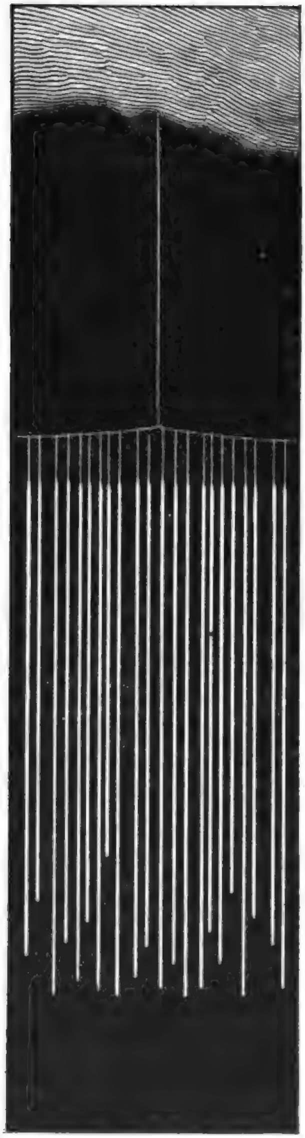
Fig. 1. Diagram of web of cave dwelling fly larva.

The whole structure is supported from the roof of the cave by a few perpendicular strands, rather irregularly spaced, usually about 2 inches long, and often 2 or 3 inches apart. The ends of these supports are connected by a horizontal cable. Where the roof of the cave is uneven the lengths of the supports are varied, so as to maintain the horizontal direction of the cable. The ends of the cable are drawn up and attached to the roof, and there is only a little sagging between the supports. The remainder of the web consists of a fringe of perpendicular threads attached to the cable above and with the lower ends hanging free. The threads of this fringe are 2 or 3 inches long, and from about 1 mm. to 3 mm. apart. A diagram, kindly prepared by Mr. W. E. Chambers of the Bureau of Plant Industry, is shown in figure 1, to illustrate the plan and appearance of the web. The drawing shows a small section of the fringe with a part of the horizontal cable and one of the vertical supports.

The cable and its supports were very slender and had the appearance of or-

dinary spider-webs, but the threads that formed the pendant fringe were much thicker, perhaps 0.5 mm. in diameter, and appeared as though filled or heavily coated with water. The thickening of the threads did not reach the junction with the cable, but began about 5 mm. below, with great regularity.

The construction of such a web implies, of course, the possession of a highly specialized spinning instinct. Indeed, without observing the operation it is not easy to understand how the webs are built unless we suppose that at least the supporting framework of the structure is first laid out on the ceiling of the cave, to be dropped into the pendent position afterward, perhaps when the heavy fringe is added. But even on this assumption the provision for keeping the cable horizontal by varying the lengths of the supports would involve a high order of instinctive skill. The stretching of the cable by carrying a thread along the wall would not seem so difficult, but more talent would be required to carry the supporting threads up to the ceiling from the cable or to let them down from above to meet the cable.

When the pendent threads were gathered upon the finger they formed a mass of slime, which shows that the material is very unlike the silk of spiders. Yet the webs evidently serve the same purpose of trapping insects. Several small insects were found embedded in the slime, from which they could be squeezed out by slight pressure. Mosquitoes and other soft-bodied forms, which have the habit of seeking dark roosting-places, probably furnish most of the victims, but one of the webs had caught a small beetle. If an investigation of the insect life of the caves were to be undertaken, these webs might afford considerable assistance in trapping the small insects that flit along the roofs of the caverns.

The larvae which were evidently the builders of these curious structures, were slender, transparent, vermiform creatures about 20 mm. long. They were found in all cases lying along the main cable of the nest, on which they seemed to slide back and forth, with considerable speed.

The attention of Mr. H. S. Barber, of the Bureau of Entomology who visited Guatemala in the same season, was called to these webs and he saw some of them in another cave near Trece Aguas.

At first he was inclined to believe that the spinning larvae might belong to the family Tipulidae, but he now considers it more probable that they are Mycetophilidae, as several other members of this family are known to spin webs or to live in web-like tubes of slime. The larval characters of this group of flies are so little known that a definite identification of the animals found in the webs is at present out of the question. But as no webs of similar construction seem to have been described, Mr. Barber has urged me to publish my notes on the subject.

The specimen secured from a web by Mr. Barber was somewhat larger and somewhat tinged with brown or black, instead of being entirely transparent like mine. Whether it represented a more advanced stage or a different species could only be conjectured. Mr. Barber also remembered that there were beads of moisture or slime on the fringing threads of the web, whereas my impression was that the threads or rods of slime were cylindrical and of constant diameter up to near the cable, where they were suddenly narrowed. Such differences might depend on the humidity of the atmosphere to which the webs were exposed.

Nothing in the way of a specialized subterranean fauna was found in the caves, unless it be the larvae that spin these webs, and even these may not be confined to the caves. Other webs that may have been made by the same kind of larvae were seen afterward in open recesses in the side of cliffs along the road between Senahú and Sepacuité, tho not in condition to compare with the much more perfect structures seen in the caves.

## ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

PHYTOPATHOLOGY.—*Studies of fungous parasites belonging to the genus Glomerella.* C. L. SHEAR and ANNA K. WOOD. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 252, pp. 1–110, pls. 1–18, text figs. 4. Issued January 25, 1913.

This bulletin contains an account of investigations of fungous parasites which produce the diseases commonly called "anthracnoses." Most cultivated fruits and many other economic plants are frequently attacked and seriously injured by fungi belonging to the genus Glomerella.

These fungi produce three distinct spore forms in the course of their complete development—conidia, ascospores, and chlamydospores, or appressoria. Until recently the two principal forms of fructification, conidial and ascogenous, have been described and treated as separate organisms, the genetic relationships not being known.

The conidial stage is most frequently found and has usually been referred to one or the other of the form genera Gloeosporium and Colletotrichum. About 500 so-called species probably belonging to the conidial stage of Glomerella have been described.

The genetic connection of the conidial and ascogenous stage of these organisms was first definitely proven in cultures in 1898 by Atkinson in the case of *Glomerella* (Gloeosporium) *cingulata* (Stonem.) S. & v. S. found on privet (Ligustrum vulgare). Since that date the life history of races, strains, or species of the organism from several other host plants has been recorded by various investigators as well as the present writers.

The life histories of forms from 36 different host plants are recorded in this paper. In 17 cases they were developed in pure culture and in the other 19 cases on the host plant, either in moist chamber or under natural conditions. In 31 cases the connection between the conidial and ascogenous stages was first reported by the writers.

In most of the forms studied neither morphological nor physiological conditions sufficient for the segregation of species have been found, but three species are recognized from the 36 hosts. *Glomerella cingulata* (Stonem.) S. & v.S. found on 34 hosts, the type on *Ligustrum vulgare*. *G. gossypii* Edge. on one host, *Gossypium hirsutum* (cotton) and *G. lindemuthianum* Shear on *Phaseolus vulgaris* (wax bean).

*Glomerella cingulata* is exceedingly variable in all its morphological characters. The cause of this variability is not clear. No constant or definite relation has been established between the environmental conditions and the most important variations observed. The fungus is found to be present in many cases on apparently normal healthy foliage fruits, and sometimes stems, as shown by its development and fructification on these plant parts after their surfaces have been thoroughly sterilized by washing with an antiseptic solution which has been shown to kill not only ascospores and conidia, but also chlamydospores or appressoria of the fungus. Germ tubes appear to penetrate the epidermis and then remain in a quiescent condition until circumstances favorable for further development occur.

Inoculation experiments with fruits show that most of the forms from different hosts will produce the characteristic bitter-rot or anthracnose of fruits of other hosts. Practically the same degree of variability is found in the virility of races or strains of the fungus from the same host as from different hosts.

The production or non-production of the perithecial stage of Glomerella appears to be a fairly well-fixed hereditary race character. The organisms of this genus have developed special features, the most important of which are its method of infection by means of appressoria, and its ability to live in a dormant or inactive condition in the tissues of the host until some specially favorable conditions for its further development occur. In many cases the fungus never develops further until the infected part of the host dies. The fungus also develops in seeds of cotton and bean especially and thus insures its passing the winter and reaching the new crop.

It has been shown by experimenters that diseases of apples and citrus fruits caused by this fungus can be satisfactorily controlled by spraying with Bordeaux mixture, and it is probable that this method can be successfully used in prevention of diseases of other plants caused by the same fungus. The selection and breeding of resistant varieties may also prove practical in some cases. C. L. S.

ANTHROPOLOGY.—*The distribution of animals and its bearing on the peopling of America.* AUSTIN HOBART CLARK. American Anthropologist, **14**: 23–30. 1912.

The land connections between North and South America, and Asia, Africa and Australia, as deduced from a study of zoogeography, are indicated, and the conclusion is stated that the connection between Alaska and northeastern Asia persisted until after man inhabited that region and therefore indicates the path by which the first men reached America. The connection between Africa and the mid-American region was disrupted so far as the zoological evidence shows, in the Cretaceous, the connection between the Australian region and southern South America was broken at a later epoch, but still too early to have formed path for human migration. A. H. C.

MEDICINE.—*An ingenious method of causing death employed by the Obeah men of the West Indies.* AUSTIN H. CLARK. American Anthropologist, **14**: 572–574. 1912.

The West Indian Obeah man of the more advanced type has learned that, on account of the high class of local medical practice, it is no longer safe to employ the common mineral and vegetable poisons which in former days served him so well. He has therefore devised a scheme of infecting flies with streptococci and then liberating them in the houses of his victims. Owing to the habits of the people, especially to their sleeping naked but with the bed clothes (if they possess them) over their heads, to guard against "jumbies" (the local species of ghost), infection is very easily brought about. A. H. C.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES.

## WASHINGTON ACADEMY OF SCIENCES

The 82d meeting of the Washington Academy of Sciences was held at the Cosmos Club, Thursday evening, January 30, 1913. Dr. Arthur L. Day gave an account of *Some observations on the volcano Kilauea in action.* The observations in question were made during the past summer in connection with a successful effort to collect, in the crater of an active volcano, lava gases uncontaminated by the atmosphere.

W. J. Humphreys, *Recording Secretary.*

## THE CHEMICAL SOCIETY

The 221st meeting was held at the Cosmos Club on January 9, 1913.

The president appointed committees as follows: *Entertainment*—McKelvy (chairman), Crenshaw, Lathrop, Smither, and Bunzel; *Communications*—Seidell (chairman), Emery (of Bureau of Chemistry), Gore, Turrentine, and Schaller.

The following papers were read: L. A. Rogers, of the Bureau of Animal Industry: *Drying by the freezing method.* This method, used for drying organic materials of all kinds, consists essentially in drying the frozen material over sulfuric acid in a vacuum dessicator. The ice crystals evaporate directly leaving a very porous and dry powder. Numerous samples were shown and the apparatus was described. The author has used the method for preserving bacterial cultures in a very concentrated and active form.

W. Salant and Clayton Smith, of the Bureau of Chemistry: *Concerning the pharmacological action of the tartrates.* Read by Dr. Salant. The wide differences in physiological action between optical isomers has been observed for a number of compounds. Contrary to the results of previous observers, the authors find that laevo- and dextro-tartartic acid are about equally active. The manner of introduction of the acid makes a great difference in the effect. A carnivorous animal, such as the cat, is much more resistant to the acid than the rabbit; the difference is not explainable by oxidation alone.

J. A. LeClerc and J. F. Brezeale, of the Bureau of Chemistry: *The effect of lime upon the alkali tolerance of wheat seedlings.* Wheat seedlings were grown in sand, clay and solution cultures containing the alkali salts sodium chloride, sulfate, and bicarbonate. Salts of calcium, barium, sodium, potassium, etc. were added in small amounts to

these cultures. It was found that the character of the medium did not affect the results. The presence of a few parts per million of calcium enabled the plants to overcome to a large extent the injurious effect of the alkali, altho the plants absorbed as much alkali in the presence of lime as they did in the control cultures. (Author's abstract.)

*Discussion:* Cameron questioned first whether the beneficial action of clay might not have been due to absorption, second whether sodium chloride found in the ash might not have been present in sap streams. In reply to an inquiry by Sosman, LeClerc stated that petroleum coke was the form of carbon used in the absorption experiments. C. C. Moore inquired as to the bearing of these experiments on the toxic excreta theory. Johnston suggested that the absorption of sodium chloride was a chemical reaction in the case of clay, and a surface effect in the case of carbon. Salant inquired concerning the effect of calcium salts alone, and Cameron stated that calcium chloride was toxic in high concentration.

H. C. Gore, of the Bureau of Chemistry: *The estimation of tartaric and malic acids by the use of uranium acetate and ammonium molybdate.* The effect was shown of increasing amounts of uranyl acetate added to solutions of free and neutralized malic and tartaric acids respectively. Excessive amount of uranyl salt were found to cause depressions in the very high optical rotations observed. In case of malic acid the depressions were slight and the maximum activity could be restored by adding optimum amounts of acetic acid; in case of tartaric acid the depressions due to excess of uranyl salt were much larger and the readings were only slightly increased by addition of acetic acid. Ammonium molybdate caused very large increases in specific rotatory power of the two acids. In the case of malic acid the maximum polarizations were much less for the neutralized than for the free acid; small additions of acetic acid stimulated the polarizations very greatly, and in presence of suitable amounts of acetic acid and ammonium molybdate the relation between the malic acid present and the polarizations was found to be linear. With tartaric acid the rotations shown when the free acid was treated with ammonium molybdate were higher than when the neutralized acid was used. The stimulating effect of acetic acid, while large, was smaller than with malic acid. Conditions were not found under which the relation between the polarizations and amounts of tartaric acid present were linear, but the specific rotatory power increased with increasing concentration. (Author's abstract.)

*Discussion:* Hillebrand suggested the use of the method inversely for the rough estimation of uranium and molybdenum in ores.

Robert B. Sosman, *Secretary.*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 264th meeting was held in the Cosmos Club, January 22, 1913, at which the following communications were presented:

*A fall of volcanic ash at Juneau, Alaska in July, 1912:* R. H. CHAPMAN. Parts of a letter from Benj. D. Stewart, dated July 28, 1912, were read, giving a description of a fall of volcanic ash due to the eruption of Mount Katmai.

*A septarian from New Mexico:* W. T. LEE.

*The habitat of the Cambrian brachiopoda:* LANCASTER D. BURLING. A study of the Cambrian and Lower Ordovician, nearly 1200 localities, represented in the United States National Museum shows: (1) that from about 72 per cent of the localities brachiopods have been identified; (2) that, dividing the sediments into three groups, shale, sandstone, and limestone, 60 per cent of the genera and 85 per cent of the species have been identified from but one type of sediment; and (3) that, after dividing the localities into three groups, figures are obtained for each of the groups, indicating that the number of species per locality is smaller in shale than in sandstone and greatest in limestone. The accordance of the results seems to justify the conclusion that habitat influenced not only the nature but the number of species which are to be found in any particular locality.

*The relations of ilmenite to magnetite in titaniferous magnetite. (Illustrated):* JOSEPH T. SINGEWALD, JR. Experiments that have been conducted in the magnetic separation of merchantable iron ore from titaniferous magnetite have yielded varying result, but in all cases only a partial elimination of titanium, and a study of the ores to show their mode of combination was undertaken. The problem was easily solved by the study of etched polished sections of the ores in reflected light. Ilmenite is unaffected by hydrochloric acid; whereas, magnetite is readily acted on, and etches to a dull black surface. On examining the etched specimens it is at once apparent that they consist of granular aggregates of ilmenite and magnetite. The magnetite grains are not homogeneous but contain minute intergrowths of ilmenite. These intergrowths are in part irregularly disseminated through the magnetite and in part regularly intergrown with definite crystallographic orientation.

*Construction of a structure map of the northern anthracite field:* N. H. DARTON. The map showing the structure of the northern anthracite coal basin has been under construction for several years and is now nearly ready for publication. It was prepared incidentally in connection with a study of the origin of methane in coal, for the Bureau of Mines. The northern anthracite basin was one of the areas selected and as one branch of the inquiry was to ascertain the relation and the occurrence of methane to the deformation of the beds the structure had to be plotted in detail in various parts of the area. The data given on the large scale mine maps, were utilized as far as practicable but in areas not reached by mining the structure was determined from surface dips aided by numerous bore hole records. The horizon selected for contouring was the lowest notable coal bed (Dunmore—Red Ash) and its configuration is

represented by 100-foot contour lines with sea level datum. The contours based on mine surveys in these lower beds are shown as full lines; those constructed from workings in overlying beds are shown by broken lines, while in areas not yet worked, dotted lines are used. The structure is still further represented by 15 vertical sections which cross the basin at frequent intervals.

Much attention was given to the extension of the different coal beds and it is now practicable to correlate all the beds thruout the basin. The investigation has incidentally disclosed structural details, showing notable discordance in the forms of the flexed beds at different depths and in harder and softer layers. It was necessary to make a very careful study of the conditions under which variations of this character occur in order to represent the probable position of important coal beds in areas not yet worked. As such a representation becomes a prediction and may affect plans for the future exploitation of coal, its occurance is a matter of great economic importance especially in the deeper basins where some of the coal lies nearly half a mile below the surface.

Frank L. Hess, *Secretary*.

## ANTHROPOLOGICAL SOCIETY

A special meeting of the Anthropological Society of Washington was held March 6, 1913 in the National Museum, the President Mr. George R. Stetson in the chair. Dr. Walter Hough read a paper on: *Savage mutilations for decoration.* The paper was a short excursion into the enormous field of custom with regard to ethnic mutilations, and sufficient examples were given to lay the subject rather completely before the society. In it were described the most striking forms of head shaping by pressure in infancy; the various forms of teeth mutilations; ear, nose, cheek and lip modifications and ornaments; pressure and mutilations in the arms, waist and limbs, and modifications of the bones of the feet. With mutilations also should be considered, perhaps, extraordinary hair dressing and treatment of the finger nails.

Many slides were shown of tatooing, scarification and decoration of the skin by means of dyes and pigments, and some of their multifarious meanings given. On the whole, it was concluded that ethnic mutilations originated from many concepts, the more important being a desire for identification, in some cases individual, but in most cases tribal; a desire for ornamentation, mainly individual in its treatment, but following environmental and tribal fashions; and also very important mutilations growing out of superstitions and religious ideas.

Many ethnic mutilations also relate to sex, puberty, social rank, honor for warlike feats, and the like. All these ideas, which at times have been advanced as the explanation of the causes, show that the matter is extremely complex. The bearing of ethnic mutilations on primitive surgery was also hinted at, as well as its effects on the development of costume.

Dr. Williams and Dr. Swanton made certain inquiries and brief remarks. The meeting then adjourned.

Wm. H. Babcock, *Secretary*.

THE PROCEEDINGS

OF THE

# WASHINGTON ACADEMY OF SCIENCES

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OF THE

# WASHINGTON ACADEMY OF SCIENCES



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# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES

Vol. III APRIL 19, 1913 No. 8

ECONOMICS.—*The function of research in the regulation of natural monopolies.*[1] E. B. Rosa, Bureau of Standards.

The social and political unrest of the present day, which manifested itself strikingly in the recent presidential campaign, is of course due to more than one cause. Senator Root in a notable speech recently delivered before the New York Chamber of Commerce, attributed this unrest in large measure to the mutual distrust and mutual misunderstanding existing between the leaders of the financial and industrial world on the one hand and the great body of the American people on the other. To a large audience of bankers, merchants, and captains of industry he said:

> There are hundreds of thousands of people outside our great industrial communities who think you are a den of thieves. There are hundreds of thousands of people who think the bankers and manufacturers are no better than a set of confidence men.
>
> We have before us now great and serious questions regarding the financial problems of the country, and this is what stands in the way of their solution: It is that the men who understand the finances of the country and the merchants engaged in great operations are under suspicion; great bodies of people will not accept what they say about finance. They will not accept what the experts say because they do not believe their motives are honest. . . . . On the other hand, what is your attitude toward the people? There are many in this room tonight who down deep in their hearts believe that great bodies of the American people really want to destroy their business and confiscate their property. Now, neither of these things is true; but one misunderstanding leads to conduct which seems to justify another.

[1] Address of the retiring president of the Philosophical Society of Washington, delivered February 15, 1913.

Senator Root then went on to say that there is nothing more important today than that by education and the spread of ideas such misunderstanding shall be done away with; that Americans shall interpret the spirit of popular government so that each shall be ready to do justice to the other, and every American shall desire the prosperity and happiness of every other American.

But while there is great force in what Senator Root says, it remains true that this social unrest springs in a measure from causes which the government can remedy.[2] The part which the government must play in our complex civilization is constantly increasing, and is immensely more important than in the simpler civilization of a century ago. In the early days the individual was much more independent, and each community was much less dependent on other communities than now. Society was simple, communication and commerce were limited, and relatively few laws sufficed. The twentieth century differs from the eighteenth in many respects, but in none more strikingly than with regard to the increasing complexity of business dealings.

The regulation and control of large corporations which have virtually secured the monopoly of particular industries is now receiving the attention of many of our leading scholars and statesmen, and the solution of the problem will be a triumph for popular government. The means that may be employed for this purpose are not so restricted as they formerly were. The public is becoming educated rapidly, and the constitution has greater capacities now than formerly.

*State regulation of natural monopolies.* While the federal government in the last few years has been striving to break up giant aggregations of corporations into their constituent parts, with the hope of getting these parts to compete with one another and so put an end to an undesirable monopoly, some of the states have been dealing in constructive fashion with another class of monopolies, and showing how they can be regulated and controlled to the end of conserving the best interests both of the public and of the stockholders. I refer to that very large and important

[2] In other words, the people acting co-operatively thru their chosen representatives can remedy.

class of corporations known as public utility companies, chief among which are the steam railways of the country, city and interurban electric railways, gas and water companies, electric light and power companies, and the telephone and telegraph companies. The federal government through the Interstate Commerce Commission has of course taken a leading part in this development, particularly with respect to the railways of the country, but the work done by some of the state public service commissions, prominent among which are the commissions of Massachusetts, Wisconsin, and New York, is of far-reaching influence and importance.

The attitude of the public regarding public utilities has been undergoing a profound change in recent years. Formerly a franchise for a street railway or gas company, for example, was usually granted without compensation to the city, with few, if any obligations on the company, with no control by the city over prices or service, and with extensions of the service into new territory optional with the Company. Competition was sometimes sought by granting a franchise to more than one company, but generally such competition, if any, made the service poorer to the public as well as the profits less to the stock holders. If the business was profitable and the franchises valuable, city councils would be corrupted, if necessary, to get what was wanted. And if the dividends were large, as they often were when no standards were set as to the quality of service and no limit set as to price, the capital would be sufficiently watered to keep down the dividends (capitalizing the value of the franchise, it was called). Occasionally a city became so dissatisfied with its gas or water or electric light company (either as to prices or service, or both) that in despair it built a new works, and two plants were operated where one, if rightly managed, would have served the public better.

*Advantages of a monopoly.* The change from this condition to the present (at least in certain states) is nothing short of revolutionary. It is now coming to be recognized that competition cannot regulate rates in public utilities, and that one company can generally give better and cheaper service than two. It is a waste of capital and a disadvantage to a city to have two sets of

gas or water pipes in the ground, or two sets of telephone or electric light wires and poles encumbering the streets. Having two telephone companies in a city forces a large proportion of their patrons to pay for both services; two street railway systems generally give less satisfactory service and fewer transfers than one would do. In short, these utilities are natural monopolies, and the highest efficiency and lowest rates are only possible when each one has the entire business of a given city or territory. So long as the right to regulate public service companies was denied, the idea of granting monopoly privileges was repugnant, and hence competition was encouraged with the hope of escaping the ill effects of unregulated monopoly. But now that the right and duty of regulating all public service corporations is admitted by the companies themselves as well as by the courts, the ill effects of monopoly may be escaped and at the same time the beneficial results of economy and efficiency may be realized. To understand what effective regulation involves, we must consider the obligations imposed upon public utility companies, and the character of the service rendered by each.

When a community grants an exclusive franchise for a term of years or for an indefinite period to a corporation, with the right to regulate the quality of the service it shall render and the prices it may charge for such service, it undertakes a serious responsibility. The interests of the public must be safeguarded, but at the same time the interests of the company and its stockholder must be respected. A public service commission, equipped with a full knowledge of the technical, commercial and legal aspects of the business, and endowed with a judicial spirit, will see that the following duties are fulfilled by each public utility company in its jurisdiction.

1. To perform any duties especially prescribed by law.
2. To serve all who request service and make no discriminations.
3. To provide safe and adequate service.
4. To charge just and reasonable rates.

5. To fulfill its duties to its stockholders honestly and efficiently.[3]

*Regulation of a gas company.* For example, a gas company receives a franchise to manufacture and sell gas for light, heat and power in a given city, for a term of years, the city perhaps to have the right of purchasing the plant at the end of the franchise period. The quality of gas and the character of the service furnished, and the prices charged, are to be fixed by the public service commission.

The commission must see that the company runs its mains into all the streets of the city; so as to give service to all, that uniform rates are charged and no rebates are allowed to favored customers; that service charges if made are reasonable; that the gas is of good quality, and as free from impurities as possible; that its heating value and candle power are kept up to the standard specified; that the methods of testing and the instruments employed are up to date and satisfactory, and the persons doing the testing are competent; that the pressure of the gas is sufficient and not too great and does not vary enough to be dangerous; that gas appliances used are as safe as can be obtained, and connected in an approved manner; that the mains are properly located and properly protected from extremes of heat and cold; that the meters are kept in good order and tested from time to time as to their accuracy; that the prices charged are as low as possible, consistent with a reasonable dividend to the stockholders; that the books are kept in an approved form, so that the state of the business can readily be determined by the commission; that proper allowances are made for plant depreciation, or proper sums expended for upkeep; that no new stock is sold without approval by the commission, and that all dividends shall be from actual earnings, but that if actual net earnings are more than necessary to pay a reasonable dividend, the price of gas shall be

[3] This of course supposes that the commission has been given the necessary authority by the state legislature. Many of the public service commissions were created as railroad commissions; and of these, some have had their functions extended to cover only a part of the duties mentioned above.

reduced. This usually involves an appraisal of the company's property to determine whether the capitalization is fair. From time to time the specifications for the quality of the gas and the methods of testing must be revised; the question may arise as to what candlepower or heating value will give the best service under prevailing conditions; new methods of manufacture, new appliances and new uses for the gas will all bring up new questions; and the commission must be prepared to consider and decide upon all kinds of scientific, engineering and commercial problems as they arise in connection with the regulation of gas companies.

These duties are so many and so varied that one might suppose that it would be impossible for a commission to accomplish them all even for a single company, much less for all the gas companies in a state. If it had never been done, it would indeed appear doubtful. But these functions are being performed (at least in large part) so successfully in a few states that many of the other states are looking forward to doing it as soon as their commissions are prepared for the work. The gain from such regulation is not alone to the public, which pays for and uses the gas. The company is saved from unfair and hostile local legislation, which often forces resort to the courts, always an expensive and often unsatisfactory experience. The business is more stable, customers are better served and better satisfied, the credit of the company is often improved, new stock sells more readily and at higher prices, as the public knows the condition of the business and there is less risk to the investor. Stock manipulation is prevented, and those who profit by that process are the only ones to suffer.

*Regulation of an electric light company.* Similar duties devolve upon a public service commission with regard to other utilities. Electric light companies are regulated with respect to their schedule of rates; discriminations which are so frequent under ordinary circumstances must be prevented; wires, whether overhead or underground, must be run in such manner as to reduce the danger to the public; high potential wires must be especially guarded to keep them from telephone and other low potential wires; alternating current transformers must be grounded on the secondary side, and the grounds must be made according to

approved specifications; the steadiness of electric potential and uniformity thruout a given city must be satisfactory; proper precautions must be taken to safeguard the lives of the linemen and other employees of the company; the meters must be frequently tested and provision made for extra tests on complaint; portable and station instruments must be tested; lamp renewals must be regulated and prices approved for other than free renewals, and rules and regulations made (in the absence of local rules) with respect to streets lights.

*Regulation of other utilities.* Street railways and interurban electric railways must be regulated with respect to kind and quality of cars; the speed of cars and car schedules; kind of brakes, headlights, doors, and other safety appliances; the method of car heating and amount of heating required; the method of car lighting and the quality and amount of light that must be supplied; how the current is distributed from the sub-stations to the cars and the variations in voltage permitted between sub-station and cars; how the railway current is returned from the cars to the sub-stations, in order that the resulting electrolysis may do the minimum of injury to gas and water pipes, lead sheathed cables and other underground structures; the repairs and upkeep of roadway and rolling stock; the fares to be charged and the conditions under which free transfers are issued; the wages paid employees and hours of labor; the conditions under which new stock may be issued; approval of plans for extensions or alterations of system; etc.

Telephone companies must be regulated with respect to method of running their wires, so as to give the best and most reliable service possible under given circumstances; when and where wires must be put underground; the precautions to guard overhead wires against coming into contact with high potential electric light or power wires; when and under what circumstances telephone and high potential electric wires may be put on the same poles; the rates to be charged for different classes of service, both local and long distance; the service arrangements between different companies, the restrictions imposed by telephone companies respecting private exchanges and extensions; discrimina-

tions by a powerful company against smaller independent companies, etc.

Both the Interstate Commerce Commission and the state commissions deal with problems arising in connection with the regulation of the railroads, and these problems are numerous and of great importance. The first class of problems is connected with the fixing of freight and passenger tariffs, and discriminations in rates as between one locality and another or between one shipper and another. The second class of problems has to do with the operation of the road, with the safety and the adequacy of the service. This includes the question of the character of the roadbed and rails, the kind and quality of the engines and cars, the brakes and signalling apparatus, the kind of headlights and the candlepower and distribution of the light from the same; the heating, lighting, and ventilation of cars; the investigation of accidents, the weighing of freight and the testing of the scales, including the scales on which empty and loaded cars are weighed. These and many other questions may come before both state and federal commissions, but not all of them have been fully considered as yet by either. Similar duties pertain also to other utilities that are essentially monopolies, as telegraph companies, express companies, sleeping car companies, water supply companies, local express, transfer, and cab companies. Insofar as these utilities carry on an interstate business, they are also dealt with by the federal interstate commerce commission.

*Co-operation necessary in regulation.* It appears from the above formidable, altho incomplete, list of duties devolving upon a state public utility commission that to fully measure up to its responsibilities would require a considerable staff of engineers, accountants, and scientific assistants, besides its traveling inspectors and administrative officers. To decide many of the questions arising requires more technical knowledge than the experts either of the commission or the utility companies possess. Indeed, many of the questions can only be answered by extended researches carried out by scientists, engineers or statisticians, working with the best of facilities. The interests at stake are in the aggregate so great that such researches ought to be made, and yet

the cost would be too great for every state to do the work independently, or even for the richest of the states to undertake it alone.[4] The best way in which the work can be well done and kept up to date is for all the states to co-operate, and for the federal government to assist and coordinate the work. This is being done to some extent already, altho comparatively few of the states as yet have commissions that are handling public utilities generally, and hence the work is only fairly begun. On the part of the federal government, the Interstate Commerce Commission and the Bureau of Standards are co-operating with the state commissions, the latter with regard to standards and engineering questions which fall within its province. Some of these questions may be mentioned briefly.

*Instruments and standards.* The instruments and standards employed in the measurement of heat, light, and electrical power, have been the subject of much study and investigation at the Bureau of Standards. The thermometers and pyrometers of various kinds employed in temperature measurements, and calorimeters of different types for use in measuring the heat of combustion of gases and solids, are calibrated and certified by the Bureau and standard samples of certified calorific value are furnished, so that the testing apparatus of public service commissions, public utility companies, and consulting engineers will agree (or special tests be made if they disagree) and causes for dispute are thereby removed. The methods of testing with such apparatus have been studied by the Bureau, and sources of error in apparatus and methods determined. As manufacturing methods are developed and refinements in works control are introduced, greater accuracy

[4] Extract from Prof. R. T. Ely, in his Outlines of Economics, 1908: "The tasks which confront such commissions are stupendous, and the expense of conducting their work, when it is properly conducted, is enormous. . . . . On the whole however, it is fortunate that the public have resolved to give this method of reform a thoro trial. It seems to be the next logical step in the evolution of natural monopoly, and does not appear to be attended with any grave danger. If it fails it will at least have trained up a corps of public servants thoroly familiar with the operation of public utility enterprises, and will at the same time have thoroly convinced the people that there is no other alternative but public ownership and operation." This was written five years ago, and much progress has been made since then.

in testing is required, and it is a great advantage to the industries to have uniform and reliable instruments, standards and methods.

The same may be said respecting the measurement of light and illumination. The candlepower of a gas flame depends upon the quality of the gas, the kind of burner used, the height of the barometer, the amount of moisture in the atmosphere, and the degree of purity of the air in which it burns; hence, if the quality of the gas is to be determined (in part) by the candlepower given, it is necessary that the test be made under very definite conditions. The Bureau has done considerable work on flame standards employed in gas testing, but much remains to be done in this respect. Photometric standards are supplied by the Bureau for use in testing electric lamps of various kinds and colors, and gas standards are calibrated and certified. Thus, uniformity of value in light measurement is secured for the whole country, and indeed by means of international comparisons made by the Bureau for the whole world, the international candle being the name of the unit of light universally employed in this country. Calibrations are also made of photometers and auxiliary apparatus. Similar uniformity, together with a much higher degree of precision, have been attained in electrical measurements. Electrical energy is sold by the kilowatt hour or the kilowatt year (or a combination of the two) and a large amount of testing is done by the companies and commissions to insure accurate measurement of the energy delivered. Here again uniformity and accuracy are promoted by having a national laboratory for calibrating and certifying standards and instruments, and settling such disputes as may arise from disagreeing measurements. A large amount of work has been done by the Bureau to secure and maintain accurate standards and instruments, but much remains to be done, particularly with reference to the specifications of instruments and apparatus and the improvement of methods of measurement and testing.

In addition to its work on instruments and standards, the Bureau has carried out other investigations which have a bearing on the work of the public service commissions. One of these is concerned with the specifications of illuminating gas, and the methods of testing to be employed in controlling its quality.

*Technical specifications for gas companies.* Among public service utilities, none has been for so long a time and in so great detail subject to legal requirements and restrictions as the gas business. Such regulation is of course intended to insure good service. Many elements go to determine good or poor service, the principal of which (chemical purity, heating value, candle-power, and condition as to pressure of the gas) are enumerated and defined more or less completely in many of the gas ordinances now in force, together with the tests that shall be made and the penalties for failure to meet the requirements. These ordinances are sometimes, therefore, very technical and contain detailed specifications. In other cases the specifications are very meager. In some cases old ordinances long since out of date, so far as their technical specifications are concerned, are still in use; in other cases, old ordinances have been extensively amended; in still other cases entirely new ordinances have superseded old ones; in many cases no regulatory ordinances have ever been adopted. In some states possessing state commissions, the requirements have been fixed by the commissions. But in most states (and in all until recently) regulatory ordinances have been prepared and passed by state legislatures or city councils. The process of adopting such an ordinance is often long and painful. Suspicion, antagonism, and often political considerations combine to make the negotiations difficult, and sometimes it amounts to a long drawn battle. The representatives of the city endeavor to get all they can for the public, the company yields as little as possible. The result is generally unsatisfactory to both. Because the standard of performance demanded of gas companies in different cities and states was so different, and because so much difference of opinion existed among experts as to what could fairly be required of a gas company under given conditions, the Bureau of Standards took up about three years ago a careful study of the subject of state and municipal regulations of the quality, purity, and pressure of illuminating gas supplied by gas companies.

*Investigation concerning regulation of gas companies.* A compilation of all the state laws and city ordinances in force in the country was first made, and their technical requirements tabu-

lated. A detailed study was then undertaken of the various features of such laws, and an attempt made to formulate a model law that should contain reasonable standards of quality, purity, and pressure, and a reasonable set of operating requirements. In this study, a large number of the best informed gas experts in the country were consulted, and many gas plants visited. In this work the Bureau has been assisted by the responsible officers and members of the technical staffs of gas companies, and by members of public service commissions, gas inspectors, and consulting engineers. The Bureau has endeavored to consider all sides of the various questions involved, and has of course received very conflicting opinions on some questions. It has been a source of great gratification to those conducting this investigation to see the fairness and broad minded spirit shown generally by representatives of the gas companies in discussing questions that affected them so vitally. They have met a spirit of fair play by a corresponding willingness to reach just conclusions.

The results of this investigation were published by the Bureau of Standards, and the paper has had a wide circulation and careful study by those most interested in the subjects treated. Since its publication, the Bureau has continued to study the subject, and is now preparing a revision of the first edition. The compilation of laws and ordinances will be revised and some important changes will be made in the model ordinance proposed. These changes are, however, being discussed very fully before publication, both with representatives of the public service commissions and of the gas companies, the latter including a special committee of the American Gas Institute.

The position of the Bureau in this matter, as in so many others, is advisory. It has no authority to enforce its conclusions and no disposition to suggest federal legislation or regulation. It acts as an unbiased co-ordinating agency, to formulate the results of its own and other's investigations and to give expression to the concensus of opinion of those best qualified to express opinions on technical questions of great practical importance.

A second investigation (already alluded to) is in progress on the methods and instruments employed in testing gas for its

heating value, its candlepower, and its chemical purity, as well as in testing meters and measuring gas pressures. This will be embodied in a separate publication which will be frequently revised and kept up to date, in order to be as useful as possible to gas inspectors and engineers in determining whether gas meets the specifications under which it is sold.

A third investigation scarcely begun, but which is much needed and deserves extensive study, is on the safety and efficiency of gas appliances. Too many fatal accidents result from defective gas appliances, and the contamination of the atmosphere thru imperfect combustion due to defective appliances is a serious matter, even when no fatalities result. This is a question in which co-operation of all the interests concerned cannot fail to yield important results.

*Investigations of electrolysis.* Another important investigation carried out by the Bureau of Standards which also concerns public utility companies is the damage by electrolysis produced by street railway currents flowing thru the earth, upon gas and water pipes, lead covered cables belonging to telephone, telegraph, and electric light companies, and the reinforced concrete foundations of buildings and bridges. Such insulated double conductor systems as those of New York, Washington, and Cincinnati provide for the return of the current to the power houses without flowing thru the earth, but most cities use the single overhead trolley, and permit the current to return in part thru gas and water pipes and other underground conductors. Where the current leaves such metal conductors, the latter are corroded electrolytically, and in some cases holes eaten thru, thereby interfering with the service and involving expensive repairs. Many remedies have been proposed, but as yet comparatively little has been done to cure the evil. The Bureau undertook a thoro study of the question for the purpose of testing some of the proposed remedies and arriving at a solution of the difficulty, if possible, that could be applied generally. This investigation is not yet completed, but already valuable results have been reached and it is hoped that shortly information will be made available for the use of the street railways that will permit them

greatly to reduce the volume of the currents flowing thru the earth without unreasonable expense, and that will enable the public service commissions to deal more intelligently with the question. The problem is becoming each year more acute since the volume of electric current used is each year increasing as the traffic increases, and the damage produced is therefore increasing at an increasing rate. Many law suits have arisen because of this damage, and such litigation is expensive because of the large amount of conflicting expert testimony adduced and the long time consumed in the trials. Money expended intelligently in solving the problem generally yields better returns than money spent in litigation.

In England and some continental countries, there have been rules on this subject which have served as a guide to the electric railways in building their roadways, and hence, they have been saved very largely from the evil effects of electrolysis, altho at a somewhat increased first cost. In this country, the subject was neglected for years. In the absence of public service commissions or similar bodies to establish regulations, and no government agency to take the lead in the investigation, the matter has been entirely neglected in many cases until the serious damage resulting has made the question a very acute one.

*Life hazard in electrical work.* Another question affecting public utility companies is the life hazard in electrical work. There are altogether too many preventable fatalities due to high potential electrical circuits not only to employees of the electrical companies but also to the public. In many cases such accidents could have been avoided if the companies had taken greater precautions, either by instructing their employees more carefully, or providing them with rubber gloves and other protective devices, or having repairs made only on dead lines, or using more substantial and more expensive construction, or running the high potential transmission lines on private rights of way instead of on the highway, or keeping the dangerous wires away from telephone wires and on separate pole lines, or taking still other precautions which experience shows are necessary. The long distance transmission of power is being resorted to more and more, and higher

voltages are being used than a few years ago would have been thought possible. One thousand volts is a dangerous voltage, but transmission at fifty to a hundred thousand volts is becoming common. As water power is utilized more and more, the country will finally be covered with a net work of high potential transmission and distribution lines, and it is a matter of vital concern that all reasonable precautions be taken in the construction and operation of such lines. So long as public utilities were regarded as private business and a company was free to make as much money as possible and invest as little as possible in its plant, the tendency was to economize unduly with respect to protective devices, and any construction that was more expensive than the mechanical or electrical requirements demanded, was avoided. But when we regard railroads, electric light and power companies, and telephone and telegraph companies not only as public utilities, but as quasi-public institutions, and permit them to charge enough to make a good profit, but to make the rates as low as good service permits, then it is seen that the public pays for the cost of protection, and it is entitled to require that every reasonable precaution be taken to safeguard human life. This latter is the view which is now becoming general, and the public service commissions are therefore greatly interested in making rules and regulations worked out in such a way as to be capable of enforcement upon the electrical companies. On the other hand, the electrical companies themselves are anxious for such information. It is not necessary to make original investigations in every case; it is often a question of collecting and digesting the information already in existence, and with the co-operation of numerous agencies which stand ready to assist, work out a body of rules and regulations that will be as useful as possible. Congress has recently made a special appropriation to permit the Bureau to undertake such a study of the life hazard in electrical work, and it is hoped that valuable results may be accomplished.

*Railroad scales.* Another investigation of great practical importance, in which the Interstate Commerce Commission and the Bureau of Standards are co-operating, is the investigation of the accuracy of railroad scales, especially car scales, for weighing

freight. Freights to the amount of two thousand millions of dollars are annually collected by the railroads on weighings made with scales, most of which are seldom tested and, except in three western states, never officially inspected. Numerous disputes and complaints could be avoided if the scales were officially tested and certified, and if provision were made for retesting on complaint. Certainly, it is as important to test large scales as small ones, and the cost of doing so is trifling in comparison with the enormous interests at stake.

*Locomotive headlights.* Another subject with which some of the state commissions have dealt is the kind of headlights used on locomotives, their candlepower and reliability. In some states legislation has been enacted requiring a particular kind of headlight. It has been charged that such legislation in some cases has been inspired by commercial interests. In one state the commission issued a rule requiring a certain candlepower but not specifying how it was to be measured or exactly what was meant. The railroads, contending that the order was ambiguous, impossible to comply with by one interpretation and undesirable by another interpretation, appealed to the courts. After a lengthy and expensive litigation, the order of the commission was set aside. This case is cited to illustrate the need of full technical information by state commissions before issuing mandatory orders, and also the hardship to railroads or other public utility companies to be obliged to contest in the courts orders that work a hardship and which would not have been issued if full information had been at hand. There is great need of further investigation of the subject of headlights for use on steam and electric railways, to determine the best service that different types are capable of giving, and to formulate rules that could be enforced by the commissions. Some railroads economize unduly on the maintenance of headlights; in the interest of safety to the public, wise regulations should be in effect.

*Car lighting.* The lighting of cars (both steam and electric) is another practical matter that has not received the attention that it deserves. Most people read more or less on trains and street cars, and with many who ride a long distance to and from

business, this is their best time for reading. As a rule, however, the lighting of cars is insufficient and the arrangement of lights is often atrocious from the point of view both of the passengers who are not reading and those who are. Eye sight is too precious a possession and too easily injured to justify the continuance of poor lighting of cars. Better light is required than would be necessary if the cars were not moving. The problem is different on electric cars from what it is on steam cars, because in the former the current for lights comes from the same circuit that supplies the motors, and hence great variations occur due to the fluctuating voltage on the trolley wire. To secure better lighting (1) a steadier voltage should be available, (2) better lamps should be used than are generally seen in electric cars, (3) a greater quantity of light should be available, and (4) the lamps should be so shaded and so located as to keep the glare out of the eyes of the passenger, and yet give good illumination for reading. The immense importance of this subject can only be realized when one considers the millions of people who daily spend a considerable time in steam or electric cars, and how much better the service would be if the cars were pleasantly and sufficiently lighted. The public service commissions have it in their power to effect an immense improvement in this respect, but first a thoro' investigation should be made, with the co-operation of the railroads, to show what are the best methods to follow, and what it is practicable to accomplish with present resources.

*Heating and ventilation of cars.* Another question of great practical importance is the heating and ventilation of cars, including Pullman sleeping cars. Any person who has sweltered in an overheated, unventilated lower berth of a sleeping car (and who has not), will allow that there is great room for improvement. Surely the resources of American invention have not been exhausted in this direction, nor, indeed, with respect to heating and ventilation of day coaches. It is one of the functions of public service commissions to see that the health and comfort of the public are kept in view by the utility companies, and if it can be made clear what should be done in this respect, the way to reform is open.

*Railway accidents.* Another line of work which deserves an immense amount of investigation and study, and co-operation between the states and the federal government, is the prevention of railway accidents. Much has been done and is now being done, both by federal and state agencies, and by the railway companies; but far greater sums of money might well be expended by the states and the federal government in a systematic investigation of all phases of this question. It is nothing short of a national disgrace that American railways should kill and injure so many more people than do the railways of European countries, even where the speeds are as high and the passenger traffic as heavy. Life is too cheap with us, and the penalty for disasters too slight. The causes of these accidents are partly physical and partly psychological; no doubt greater attention given to the subject of how to prevent both kinds of accidents would be abundantly rewarded.[5]

Other subjects deserving research could be named that fall within the province of the public service commission, but enough has been said to show how important are their functions apart from the duty of fixing rates and preventing discrimination. These illustrations show how much better it is for the public as well as the companies that the commissions regulate by co-operating with and assisting the companies instead merely of dictating to them what they shall do or shall not do; that the scientist, the engineer, and the statistician are more useful to them in their work than the lawyer; that the bar of public opinion is more effective than the courts in enforcing their decrees. Many of these utilities are operated by big corporations, owning scores of plants in many states; in the case of the telephone and telegraph,

[5] A recent writer states that 19,377 more persons were injured on railroads in the United States in 1912 than in 1911, and commenting on the slight amount of scientific information that has been collected regarding the causes of accidents, he adds:

"The railroads of this country carry so many passengers and so much freight that in one year they are able to charge three billion dollars for the service. And yet it is admitted that no accurate engineering data showing the actual stresses which are set up in railway structures by locomotives and cars of different weights and moving at different speeds has ever been gathered."

they are gigantic systems operating over the whole country. It is therefore important that the rules and regulations in the different states shall be as nearly uniform as possible. Hence, in order to reach wise and just conclusions, and to secure uniformity, it is important that the states co-operate with one another, and the federal government can serve as a valuable aid and co-ordinating force in this co-operation.

The results that are being attained in this way are only beginning to be realized. They will be of invaluable benefit, not only to the public served, but to the companies themselves, and to the cause of good government. With the utility companies under the control of business-like state commissions, the business is better managed,[6] discriminations in rates are eliminated,[7] the utilities are taken out of local politics, and the possibility of pure municipal government in America is enormously enhanced.[8]

[6] B. H. Meyer, speaking on the Wisconsin Public Utilities Commission, at the Pittsburgh Meeting (1908) of the National Municipal League, said:

"The utility law is working a revolution in business management. . . . . Many of the utility companies have not been operated on a business basis; in fact, it is probable that a good many of the managements did not have the remotest idea as to the exact standing, from a business point of view, of the plant, they were operating. Uniform accounting and rules governing the service and the regulation of ratio, compel the adoption of business and scientific methods. This is resulting in nothing short of a revolution in management."

[7] The whole state of Wisconsin was literally streaked and plastered with discrimination in the rates of utilities, and in all the rest of the country, where the extent of the discriminations have not yet been determined, as they have been in Wisconsin, it is quite probable that discriminations similar in character and extent likewise exist."

[8] Governor McGovern has this to say regarding the utilities and politics in Wisconsin:

"Times were in Wisconsin when the railroads ran or tried to run the government of the state, and the minor utilities sought to boss the cities, towns and even villages. They contributed liberally to campaign funds, urged their supporters and lobbyists to become candidates for public office, and in close election districts colonized voters in the old conventional way. Now, one and all, they are in this sense absolutely out of politics. There is, indeed, no reason now why public service corporations in Wisconsin should wish to dabble in public affairs. Their relations to the people of the state have been definitely and finally determined. They no longer have anything to gain or lose by intermeddling in politics, and apparently they have decided to retire for good. What the elimination of public service corporations from participation in political campaigns signified in the purification of public life, no one here needs to be reminded."

One of the best results of the method of regulation by public service commissions is the publicity it secures of the affairs of the company and the confidence it establishes in the public mind in the various utility companies. The suspicion and distrust which Senator Root emphasized so strongly in his New York address is everywhere felt toward these companies when their affairs are kept secret, and especially when the service is poor and the dividends good. Controversies arise which sometimes degenerate into bitter and partisan feuds. Who can feel kindly toward the management of a street railway company if he is usually compelled to ride as a strap hanger, or toward a gas company if the rates are excessive or he believes that his meter races, or toward any company that appears to regard its franchise as the deed to a private monopoly. If the service is improved or the rates reduced as the business grows more prosperous, the people as well as the stockholders derive benefits from success. The public soon realizes that utilities so conducted are in effect partnerships between the public and the stockholders, and are willing that the latter receive increased dividends with increased prosperity if the public is permitted to share the fruits of success. The sliding scale of prices for gas is a successful example of this system, but it is also realized in many cases where a sliding scale of prices has not been fixed in advance. The regulation of prices by a commission gives in effect a sliding scale, by which either the price goes down or the quality of the service goes up, as the success of the business justifies it. For want of a Public Service Commission in the District of Columbia, the Interstate Commerce Commission has recently been exercising the functions of such a commission with respect to the street railways, and with good effect. There is great need of a full fledged Public Service Commission in the District, and it is hoped that Congress in its wisdom will respond to public sentiment and establish such a commission.

How infinately better is this method of regulation than the building of publicly owned utilities to compete with private plants already in existence. For a state or city to say that it is impotent to regulate a public utility is a confession of weakness; but there is far greater difficulty in city control than in regulation by state commissions. Except, perhaps, in the largest cities, it seems

much better to have strong state commissions, well equipped with technical assistants, than to have separate commissions for each city. And with the co-operation of other states and the federal government, any state commission can establish its work with only a fraction of the effort and expense required by those states that have pioneered the movement.[9]

Turning now to the great industrial and financial corporations popularly called trusts, the question suggests itself whether it is possible for the government to regulate them in a manner similar to the regulation of the natural monopolies we have been discussing, so that full publicity may be secured, the rights of the public may be conserved, and at the same time the rank and file of the stockholders will be protected from the vultures that often hover over the executive offices of such concerns. One cannot say that it will be done as easily, but it is coming to be believed that the general method adopted in the regulation of public utilities is the right one, namely, less dependence on law and the courts, and more dependence on engineers, statisticians and business experts; that the government should prescribe affirmative duties for the giant corporations, and not merely negative ones; that a constructive policy that would benefit both the business concerns and the public they serve should be sought, rather than a retrograde policy that is no benefit to the business and does no good to the public. If such regulation could be realized, and consolidations and promotions in business could be limited to such as would benefit both the public and the stockholders, and not merely big financiers and promoters, it would be a notable achievement in our political as well as economic history. It would assist mightily in the peaceful settlement of industrial disputes and in the bringing of a better understanding between capital and labor.

It is just as reasonable to expect the government to perform this function of regulation of monopolies as to expect it to adjust international disputes by arbitration rather than by war. It is not socialistic, but rather the reverse, for it is the alternative of state ownership. In Germany the cities are great business

[9] Writing in 1908, Professor Ely said: "States having commissions empowered to enforce uniform accounting will constitute great economic laboratories in this connection during the next quarter of a century."

concerns operated by business men for the benefit of the people, and as such they are models for the whole world. They own and operate most of the public utilities themselves, and do it well, and hence the necessity of public regulation is there less felt altho it has been practiced for many years. But in this country, municipal ownership has been less successful, except in the case of municipal water supplies.

There have been three stages in the modern history of natural monopolies. In the first they went unregulated, being operated for the profit of the owners and exploited for the benefit of financiers. In the second stage, regulation was by legislation and law suit. In the third, regulation is by commission; the regulation is more complete, as well as more intelligent, and co-operation and publicity are the keynotes of the method.

The large industrial corporations which have virtual monopolies, are mainly in the first stage, altho some are in the second. Whether they will finally come to the third stage, and be regulated by the methods now applied so successfully to natural monopolies, remains for the future to determine.

If state regulation of natural monopolies becomes as general within a few years as it promises to be, and if it is as successful generally as it has been in the few states which took it up first, it will solve the problem of public utilities and largely solve the problem also of good municipal government.

The signal success of the Wisconsin Commission was largely due to the influence of the University of Wisconsin. In its personnel and methods it was a scientific commission, and entered into its work with the spirit of the investigator. Its spirit and its methods have been adopted by some of the other state commissions, of which a larger number have been created recently and are now taking up their work.

If the administrative officers of the commissions are assisted by scientists, engineers, and economists, and the work is done in a judicial spirit, as new problems being taken up as a scientific research would be, the states and federal government acting in full co-operation, with the experience of each available to all; if the work is done in that way we may be certain that success will be sure and permanent.

MINERALOGY. *The determination of the order of agreement between observation and theory in mineral analyses.*[1] FRED. E. WRIGHT, Geophysical Laboratory, and C. E. VAN ORSTRAND, Geological Survey.

In a recent number of this Journal,[2] Dr. W. T. Schaller published an interesting note on "The Calculation of Mineral Formulas" in which he showed that the ordinary method of calculation—by first reducing the weight percentages of an analysis to mol numbers[3] and then dividing these by one of the mol numbers thus obtained—furnishes results whose degree of approximation to whole numbers is less than that of the values derived by a new method of calculation which he described. In view of the fact, however, that certain details of his method are open to criticism, it has seemed appropriate to the present writers to consider the principles underlying the subject, and to determine if possible the most logical basis and method for comparison. From Schaller's paper, the mineralogist or chemist may perhaps be led to infer (1) that the ordinary methods of calculation furnish only a rough measure of the degree of approximation of a chemical analysis of a mineral or chemical compound to the values derived from its chemical formula; and (2) that by a somewhat involved calculation the analysis can be expressed in more accurate form.

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] Jour. Wash. Acad. Sci., 3: 97–98. 1913.

[3] The term *mol number* is here suggested as an appropriate name for the number obtained by dividing the weight percentage of a chemical substance in any given chemical analysis by its proper molecular (respectively atomic) weight. Such numbers have usually been called *molecular ratios*, but they are, rather, numbers indicating the number of mols (gram-molecules) of each substance present in $n$ grams of the material analyzed where $n$ is the sum of the analysis. The terms *molecular ratios* or *molecular proportions* apply logically only to the numbers of the chemical formula. Thus in the analysis cited below, the chemical formula numbers or molecular ratios are

$S : As : (Ag + Cu) = 11 : 2 : 8$, while the mol numbers from the analysis are $S = 0.5444$; $As = 0.1008$; $(Ag + Cu) = 0.3975$. To use the term molecular ratios indiscriminately for both sets of numbers is not conducive to precise statement and is not to be recommended. The term *mol number* seems preferable to *molecular number* or molecular quotient (Molekularzahl Molekularquotient) which are in current use in German. The writers are indebted to Drs. Washington and Niggli for detailed discussion of the proposed term.

The underlying purpose of such calculations is not, however, to improve a chemical analysis by mathematical manipulation, which is obviously impossible, but to obtain a logical basis of comparison for the given analysis with the analysis calculated from the chemical formula. In the following paragraphs the different methods which are available for such comparisons will be discussed with reference to their accuracy and general applicability. It will be shown that the best general method is to compare the actual analysis of the mineral with the weight percentage analysis derived from its chemical formula. This method is, moreover, in common use. The method suggested by Schaller is not only inferior to this and to the other methods considered below, but it is incorrect in principle in certain details.

The problem is based on Dalton's fundamental law of simple atomic or molecular ratios, namely, that in a homogeneous chemical substance in which the relations are not veiled by solid solution, the atomic and molecular proportions can be expressed by small whole numbers. In practice, however, we find that because of various sources of error (lack of purity of material analyzed, inaccuracy in chemical methods and impurities in reagents employed, errors in atomic weights, personal equation of analyst), the actual data of a mineral analysis, after reduction to mol numbers, only approximate whole numbers in their ratios, the deviations being usually small and to be treated as errors of observation. In the present problem, only the final results of an analysis are given and the above sources of error can not therefore be differentiated and properly weighted, but have to be considered together and all analytical data equally weighted. It should be noted that in chemical data of this character, the systematic errors are relatively large, and that, furthermore, they can not be distinguished in the analytical data, as given, from the accidental errors. Too refined mathematical treatment is, therefore, unnecessary and misleading. For the sake of completeness, however, the various available methods will be considered below, even tho several of them are hardly to be recommended for the reasons cited above.

From the mol numbers of an analysis we infer by inspection the

molecular ratios or simple chemical formula numbers, and then proceed to determine how close the agreement is between the observed values and those deduced from the inferred chemical formula. This can be done by several different methods, which, however, are not all equally rigorous. The best and most logical methods are based on a comparison between the given analysis (weight percentages) and the weight percentage analysis computed from the inferred chemical formula. Comparisons can also be made between the mol numbers and the inferred molecular ratios, but these are not strictly correct in principle. They have, however, often been adopted, by chemists and mineralogists, and merit, therefore, a brief word of description after the more rigorous methods have been presented in detail. In all the methods the assumption is made that after proper reduction of the weight percentages of the given mineral analysis, the chemical formula numbers (molecular ratios) can be inferred by simple inspection; this signifies that in the case of solid solution we know, or are able to determine, the particular molecules which should be considered together.

*First method.* In this method the chemical formula numbers are first multiplied by the proper molecular (respectively atomic) weights and the corresponding weight numbers ($x$) obtained. These in turn are multiplied by a factor $m$ which is determined by the least square method and furnishes the most accurate values ($y'$) for the weight percentages. To find $m$ we assume in accord with usual practice that the theoretical weight numbers ($x$) derived from the molecular ratios are free from error and that the observed quantities ($y$, the weight percentages of the analysis) contain errors of observation. Since the two series of numbers stand in a constant ratio $m$ to each other we have the observation equations

$$y_1 = mx_1,\ y_2 = mx_2,\ .\ .\ .\ y_n = mx_n. \qquad (1)$$

The general equation, $y = mx$, is the equation of a straight line passing thru the origin. The rigorous solution consists, therefore, in adjusting the straight line thru the $n$ given points. A higher degree of precision would be obtained by considering the

origin as an observed point but this assumption seems in the present instance unnecessary and incorrect in principle.

To obtain the required solution let the equations be put in the form

$$p_1y_1 - mp_1x_1 = p_1v_1,\ p_2y_2 - mp_2x_2 = p_2v_2,\ .\ .\ .\ p_ny_n - mp_nx_n = p_nv_n \quad (2)$$

in which $v_1, v_2$ . . . $v_n$ are the respective residuals or the differences between the observed values ($y_1, y_2$, . . . $y_n$) and the computed values ($y'_1$, $y'_2$, . . $y'_n$); $p_1, p_2$, . . $p_n$ are arbitrary weights assigned to the corresponding observation equations. By making now the sum of the weighted squares of the residuals ($p_1v_1^2 + p_2v_2^2 +$ . . . $+ p_nv_n^2$) a minimum we obtain the best possible solution of the equation for $m$, namely,

$$m = \frac{p_1x_1y_1 + p_2x_2y_2 + \ .\ .\ .\ + p_nx_ny_n}{p_1x_1^2 + p_2x_2^2 + \ .\ .\ .\ + p_nx_n^2},$$

an expression which reduces to

$$m = \frac{x_1y_1 + x_2y_2 + \ .\ .\ .\ + x_ny_n}{x_1^2 + x_2^2 + \ .\ .\ .\ + x_n^2} \quad (3)$$

when we assume that the weights ($p_1$, $p_2$, . . . . $p_n$) to be assigned to the observation equations are all unity.

To apply this method to the analysis cited by Schaller we ascertain first the mol numbers (Column 2) by dividing the weight

| | 1 | 2 | 3 | 4 | 5 | 5a | 6 | 6a | 7 | 7a | 8 | 8a |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WEIGHT PERCENTAGES ($y$) OBS. | MOL NUMBERS | MOLECULAR RATIOS | WEIGHT NUMBERS ($x$) | WEIGHT PERCENTAGES ($y'$) COMP. | RESIDUALS $o-c$ | | $o-c$ | | $o-c$ | | $o-c$ |
| S | 17.46 | 0.5444 | 11 | 352.79 | 17.53 | −.07 | 17.54 | −.08 | 10.981 | +.019 | 10.964 | +.036 |
| As | 7.56 | 0.1008 | 2 | 150.00 | 7.45 | +.11 | 7.45 | +.11 | 2.033 | −.033 | 2.030 | −.030 |
| Ag | 59.22 | 0.2744* | | 1191.85 | 59.21 | +.01 | 59.24 | −.02 | | | | |
| | | | 8 | | | | | | 8.018 | −.018 | 8.006 | −.006 |
| Cu | 15.65 | 0.1231* | | 314.97 | 15.65 | .00 | 15.66 | −.01 | | | | |
| | 99.89 | 1.0427 | 21 | 2009.61 | 99.84 | | 99.89 | .00 | 21.032 | | 21.000 | .000 |

* Considered as ($Ag_2$) and ($Cu_2$) respectively. Sum = 0.3975

percentages of column 1 by the proper atomic (respectively molecular) weights;[4] from these mol numbers, we have

$$S : As : (Ag_2 + Cu_2) = 0.5444 : 0.1008 : 0.3975$$

and infer that the correct chemical formula numbers are

$$S : As : (Ag_2 + Cu_2) = 55 : 10 : 40 = 11 : 2 : 8.$$

These numbers (column 3) are then multiplied by the proper atomic (respectively molecular) weights and the $(x)$ values of the equations (1) obtained (column 4). The value of $m$ is now found from equation (3) by dividing the sum of the products of the observed values $(y)$ (column 1) and the theoretically correct values $(x)$ (column 4) by the sum of the squares of $(x)$. On multiplying the $(x)$ values by the value of $m$ $(= 0.049682)$ thus computed we find the values in column (5); the differences between the observed $(y)$ and computed $(y')$ values $(o - c$, column $1 -$ column 5) are a proper measure of the degree of approximation of the actual analysis to that computed from the inferred chemical formula. The rigorous test would consist in computing the probable error of a single observation but this procedure is perhaps unnecessary for data of the character here considered.

*Second method.* This method is a mathematical refinement of the first method but it does not give values which are of sufficiently greater precision to warrant the extra labor involved in computation nor does the assumption that $(x)$ contains errors of observation seem to be rigorously justified unless errors in the atomic weights are of sufficient magnitude to be taken into account. In this method it is assumed that both the $(x)$ and the $(y)$ values of equations (1) contain errors of observation. The proper value of $m$ to meet the conditions is then obtained from the equation

$$m^2 - \left(m_2 - \frac{1}{m_1}\right) m - 1 = 0 \qquad (4)$$

wherein

[4] In his paper Schaller did not state the atomic (respectively molecular) weights which he used in his computations. They are readily found, however, by dividing the numbers of the first column by the corresponding ones of the second. They are $S = 32.07$; $As = 75.00$; $(Ag_2) = 215.82$; $(Cu_2) = 127.13$.

$$m_1 = \frac{x_1y_1 + x_2y_2 + \quad . \quad . \quad . \quad + x_ny_n}{x_1^2 + x_2^2 + \quad . \quad . \quad . \quad + x_n^2}$$

$$m_2 = \frac{y_1^2 + y_2^2 + \quad . \quad . \quad . \quad + y_n^2}{x_1y_1 + x_2y_2 + \quad . \quad . \quad . \quad + x_ny_n}.$$

In these equations the weights of ($x$) and ($y$) and of all observation equations are assumed to be unity; $m_1$ is the value of $m$ in equations (1) when ($x$) is assumed to be correct and ($y$) to contain the errors of observation; $m_2$ is the value of $m$ in equations (1) when ($y$) is assumed to be correct and ($x$) to contain slight errors. On applying this method to the above analysis we find that the values obtained are identical with those in column 5 to the second decimal place.

*Third method.* The results obtained by this method are only approximately correct but they are of sufficient accuracy to be satisfactory for most analyses and are, moreover, readily computed, the computation consisting simply in reducing the weight numbers ($x$) (Column 4) proportionately, so that their sum (column 6) is equal to that of the given analysis (column 1), the assumption being that when the two analyses have the same sum (either the actual sum of the given analysis or 100.00), we have a common basis for comparison. The differences (column 6a) between the observed weight percentages (column 1) and those computed by this method (column 6) are then an approximate, but satisfactory measure of the agreement of observation with theory. This method is, for general purposes, the simplest and best. Mathematically it can be stated from a somewhat different viewpoint, altho the computations are the same. If we assume that the sum of the weighted residuals ($p_1v_1 + p_2v_2 + \quad . \quad . \quad . \quad + p_nv_n$) in equations (2) is zero, the resulting equation gives

$$m' = \frac{p_1y_1 + p_2y_2 + \quad . \quad . \quad . \quad + p_ny_n}{p_1x_1 + p_2x_2 + \quad . \quad . \quad . \quad + p_nx_n}, \qquad (5)$$

an equation which reduces to

$$m' = \frac{y_1 + y_2 + \quad . \quad . \quad . \quad + y_n}{x_1 + x_2 + \quad . \quad . \quad . \quad + x_n} \qquad (6)$$

when we assign equal weight to all the observation equations. In Schaller's analysis, the factor

$$m' = \frac{99.89}{2009.61} = 0.049706$$

which is only slightly different from the factor $m$ obtained by the least square method. To find the required value for S in the above analysis by this method, we multiply the weight number 352.79 (column 4) by the factor $m' = 0.049706$ and obtain the value 17.54 listed in column 6; the remaining values of column 6 are obtained from column 4 by multiplying by the same factor.

To impose the conditions (1) that the sum of the residuals shall vanish and (2) that the sum of their squares shall be a minimum, we write the observation equations in the general form

$$y = a + mx,$$

and adjust them by the usual least square method. There seems, however, to be no justification for adopting such a procedure here.

*Fourth, fifth and sixth methods.* These methods are identical with the three preceeding methods except that the adjustments are made between the mol numbers and the molecular ratios. Thus the mol numbers may be taken as the observed values ($y$) and the molecular ratios as the theoretically correct values ($x$) to be used in the observation equations (1). Adjustment can then be made by any one of the methods described above. Thus in method (4), the factor $m$ of observation equations (1) is found from equation (3) by considering the mol numbers (column 2) the ($y$) values and the molecular ratios (column 3) the ($x$) values. The final values are then obtained by multiplying the ($x$) values (column 3) by the factor $m$ thus computed. In method (5) the same values of ($x$) and ($y$) are used and the proper value for $m$ computed from equation (4) above. Similarly in method (6) the proper value for $m'$ is computed from equation (6). The results obtained by these three methods are, however, theoretically inferior to those of the first three methods, for the reason that the mol numbers are obtained from the weight percentages by dividing them by the proper molecular (respectively atomic)

weights, and are therefore differently weighted because the molecular (respectively atomic) weights are different. In the present case these objections do not seriously affect the results obtained, but the objection is nevertheless valid and the methods are in error to that extent.

*Seventh, eighth and ninth methods.* In these methods the adjustments are made on the assumption that the mol numbers are theoretically correct ($x$ values), while the molecular ratios ($y$) contain the errors of observation. This is a still further departure from correct theory, and neither these methods nor those noted in the last paragraph are to be recommended. The values obtained by the seventh method involving adjustment by least squares are listed in column 7, while the differences ($o - c$) between columns 3 and 7 are given in column 7a. Similarly, the results obtained by use of the ninth method, which corresponds to method 3, are given in column 8 and the differences ($o - c$) in column 8a. It may be noted here that insofar as the numerical computations are concerned, it is immaterial which set of quantities ($x$ or $y$) are assumed to contain errors of observation when equation (6) is used, but different results are obtained when the quantities are adjusted by means of equations (3) and (4).

*Schaller's method* is in error in the following details of principle:

1. Comparisons are made between mol numbers and molecular ratios on the assumption that the mol numbers are theoretically correct while the molecular ratios contain the errors of observation. The objections cited under methods 7 to 9 apply, therefore, to his method.

2. The numbers given in his column (2), page 98, are of unequal weight and the arithmetic mean is not, therefore, a correct average.

3. The final values in his last column near the bottom of page 98 are obtained by dividing the computed numbers in his column (3), page 98, by the molecular ratios. These values are accordingly of different degrees of approximation because differently weighted.

4. His method may be stated in the form of an equation by putting

$$p_1 = \frac{1}{x_1},\ p_2 = \frac{1}{x_2}\ \ .\ \ .\ \ .\ \ p_n = \frac{1}{x_n}$$

in equation (5). Since the weights are here inversely proportional to the $(x)$ values, it follows that small molecular ratios are adjusted more accurately than the larger numbers.

*Summary.* Of the methods available for comparing the observed results of a mineral analysis with those obtained from the chemical formula to which the analysis corresponds approximately, the best method is to ascertain first the weight numbers (derived from the chemical formula by multiplying these ratios by the proper molecular weights), and then to adjust these values to the given analysis by the least square method. Since the computations involved are, however, somewhat laborious, and furthermore, since there are a limited number of observations and the systematic errors of observation are, in general, large as compared with the accidental errors, the simple method (3) (equation 6) is preferable for general use. It furnishes results which are very nearly correct and consists simply in reducing the weight numbers proportionately so that their sum is equal to that of the given analysis. In other words, we compare the actual analysis directly with the weight percentage analysis computed from the inferred chemical formula, both analyses having a common sum. The differences between the observed and computed values are then a sufficient measure of the degree of agreement of observation with theory. The two general formulas (3) and (6) furnish the best solutions of the present problem. In these formulas $y$ may be taken to represent weight percentages, mol numbers or molecular ratios, while $x$ represents respectively the weight numbers, the molecular ratios or the mol numbers. Equation (3) always gives a more precise adjustment, but equation (6) is in general sufficiently accurate for the computations here considered. The relation between weight percentages and weight numbers is rigorous. The relations between mol numbers and molecular ratios are lacking in rigor, but are usually sufficiently accurate for the purpose.

PHYSICS.—*A new thermal microscope for the measurement of the optical constants of minerals at high temperatures.* FRED. EUGENE WRIGHT, Geophysical Laboratory.

With this microscope (fig. 1) three optical constants—birefringence, extinction angle, optic axial angle—of a properly ori-

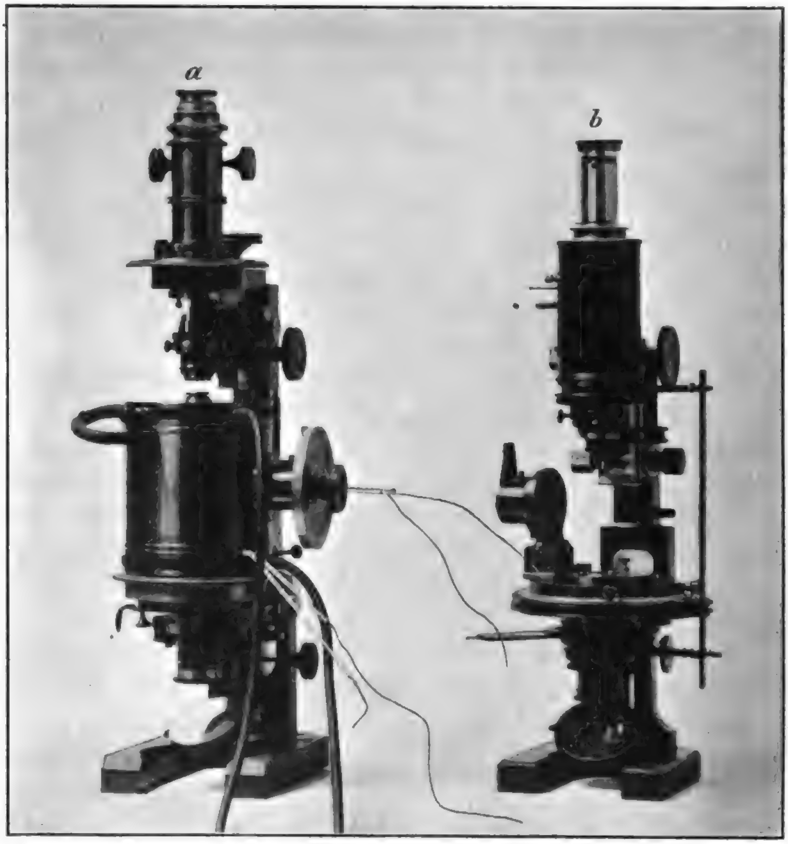


Fig. 1

ented crystal plate can be measured accurately at any temperature between 10°C and 1200°C. Above 1200° the intensity of illumination from the furnace itself is so great that it tends to veil the optical phenomena produced by the polarized light waves transmitted thru the plate. The thermal microscope consists

of two distinct parts: (1) a petrographic microscope equipped with a suitable device for simultaneous rotation of the nicols, either by means of gear wheels connected by a bar (fig. 1a) or by means of a direct connecting bar (fig. 1b), the second method being the more accurate and satisfactory; (2) an electric resistance furnace *A* (fig. 2) which is enclosed within the water jacket *W* (fig. 2). The details of construction of this furnace are shown in vertical section in figure 2. The furnace consists of two alundum

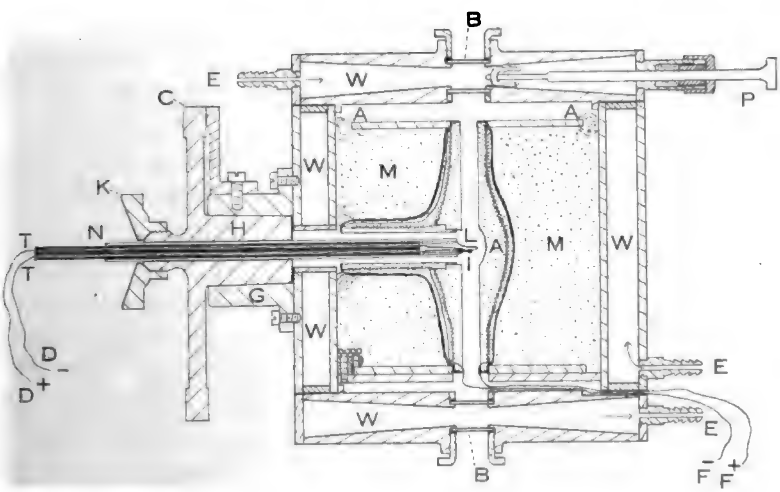


Fig. 2

tubes made especially for the purpose and wound on the outside, in helical grooves of 1 mm. pitch, with platinum wire 0.35 mm. in diameter. It is then coated with alundum cement and finally baked at 1200° to 1400° for several hours. In this furnace the relatively small openings at the ends and the side, the enlargement at the center and the close winding of the heating coil are arranged to insure uniformity of heating in the central space where the crystal plate is heated and its temperature measured.

The water jacket consists of a hollow brass cylinder and separate hollow end plates each of which is provided with an intake and outlet *E* for the circulating water. Into each end plate a plunger *P* is fitted for wiping away the air bubbles which happen

to collect between the two glass windows *B* and thus to disturb the field of view. To the cylinder part of the jacket a support *G* is attached with conical center bearing for the crystal holder. The crystal plate whose optical constants are to be determined is held in position by platinum jaws (*L* fig. 2) which fit into and project beyond the porcelain tube *N*, which in turn is held in position by the rotating holder *H*. The thermoelement wires *D* are passed thru the larger tube *N* in small porcelain tubes *T* and extend beyond these so that the thermoelement junction is directly beneath or above and in contact with the mineral plate, thus insuring good temperature readings. The temperatures are read either on a direct reading millivoltmeter (Siemens and Halske type) or in more accurate work by means of a mirror galvanometer and potentiometer system as commonly used in this laboratory.[1] The holder *H* is equipped with a circle *C*, graduated to degrees, and with a clamp screw *K* for keeping the tube *N* in place. This part of the apparatus is complete in itself and can be withdrawn from the furnace at any temperature without disturbing the other parts. To insure proper adjustment of the crystal plate a second holder (fig. 1b) is clamped to the stage of a second microscope and the plate so mounted that the plane of its optic axes is normal to the axis of rotation of the holder.

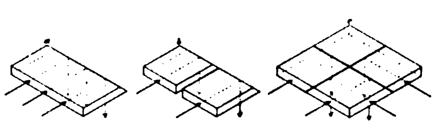

**Fig. 3**

For this adjustment a device for autocollimation has been used which has proved serviceable and promises to be of value in other autocollimating instruments. A thin cover slip of the shape indicated in figure 3a with one edge vertical and the opposite edge inclined 45° to the vertical, is placed in the rear focal plane of the low power objective. Light from a Nernst filament, sent thru the plate to the inclined edge, is totally reflected

[1] Carnegie Institution of Washington, Pub. **31**, 1905; **157**, 68, 1911.

and passes thence through the objective to the mineral plate, where it is again reflected and appears, after its return through the objective, as a sharp bright line in the dark field. When the mineral plate is normal to the axis of the lens system, the bright line is practically covered, thus enabling the observer to make very accurate adjustments.[2]

This method has been improved by using two cover glasses as indicated by figure 3b, the space between the glasses serving to mark the center. The complete cross has also been obtained by means of cover glasses ground as illustrated in figure 3c. The grinding and mounting of four such cover glasses is, however, difficult and requires considerable skill to be accomplished satisfactorily.[3]

After the crystal plate has been mounted and adjusted and the thermoelement wires correctly placed, the holder *H* is inserted into its support *G* on the water jacket (fig. 2) and the mineral plate thus introduced into the furnace in a position ready for the measurement both of its optical constants and of its temperature.

The *birefringence* of a mineral plate is measured on this microscope by the method used on the thermal microscope described several years ago.[4] The thickness of the plate is determined before insertion into the furnace. The change in thickness due to expansion on heating is so slight that it is negligible for most measurements of birefringence. The path-difference of the emergent waves from the crystal plate in the furnace is measured by means of a graduated compensating wedge.[5]

*Extinction angles* are measured by means of a biquartz wedge

[2] This scheme for autocollimation is somewhat similar to that suggested by Nutting in this Journal **2**, 404, 1912. In his arrangement a reflecting cover glass is used on end with the result that only a small part of it is in focus at any setting of the eyepiece while in the scheme outlined above the entire cover glass is in sharp focus and the field is less disturbed.

[3] These different types of cover glasses were satisfactorily ground for the writer by the Bausch and Lomb Optical Company.

[4] Am. J. Sci. (4) **27**, 43. 1909.

[5] Am. J. Sci. (4) **29**, 417. 1910; Carnegie Institution of Washington, Pub. **158**, 102. 1911.

plate[6] combined with rotating nicols. This plate is useful for determining positions of total extinction of a mineral even at high temperatures where the strong illumination of the furnace field tends to cover up the interference colors from the mineral plate.

The *optic axial angle* is measured directly on the graduated circle $C$ (fig. 2), the crystal plate being rotated until each of its two optic axes coincides with the axis of the microscope (tested by rotation of the nicols, as in the universal stage methods); the angular distance between the two positions of coincidence is read directly on the graduated circle. These positions are sharply marked and the error of the measurement of the optic axial angle on a favorable section is not over $\pm 1°$ even at relatively high temperatures.

This thermal microscope has proved so satisfactory in practice that an extended series of measurements on selected natural minerals of known composition has been commenced with a view to determine not only the changes in their optical constants but also their inversion and melting temperatures, these last temperatures to be checked by means of the accurate temperature measuring methods now in use in the Geophysical Laboratory. At the same time the refractive indices and in some instances changes in crystal angles will be ascertained by the use of another furnace attached to the two circle goniometer and to be described in a later communication.

[6] Am. J. Sci. (4) **26**, 377, 1908; Carnegie Institution of Washington, Pub. **158**, 139. 1911.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 265th meeting was held in the lecture room of the Cosmos Club, February 12, 1913.

An informal communication was presented:

*Cone in cone structure in coal from St. Anthony, Idaho:* E. G. WOODRUFF. Cone in cone structure is not uncommon in clay and shale, but unusual in coal. The specimens exhibited from the St. Anthony coal-field, Idaho, show this structure well developed on the surface but not developed within the specimens, tho shearing is shown. Bed from which the sample is taken is crushed and faulted. Slickensiding is common. The cone in cone genetically in this case seems to be closely related to slickensiding. The complete explanation is not offered.

The formal communications were:

*Certain metallic minerals as precipitants of silver and gold.* CHASE PALMER and EDSON S. BASTIN. The paper will be published in no. 2, vol. 8, of Economic Geology, and in shorter form in the Transactions (New York meeting) of the American Institute of Mining Engineers.

*Time relations of glacial lakes in the Great Lakes region:* FRANK LEVERETT. The following tabulated statement of the order of development of lakes in the several basins sets forth the tentative correlation based upon a study of the moraines, lake outlets, and other features which bear upon correlations. The writer is responsible for the present tabulation but is indebted to various other geologists for data bearing upon the direction of outlet of the several lakes at different lake stages.

*Order of development of glacial lakes*

1. General recession of ice border but with some oscillation.
   Lake Maumee, discharge (a) By Fort Wayne to Wabash River.
   (b) By Imlay outlet to Lake Chicago.
   Lake Saginaw, discharge in later stage by Grand River outlet to Lake Chicago.
   Lake Chicago, discharge by Chicago outlet to Illinois River.
2. General recession of ice border.
   Lake Arkona, discharge by Grand River outlet to Lake Chicago.
   Lake Chicago, discharge by Chicago outlet to Illinois River.

3. Readvance of ice border.
   Lake Whittlesey, discharge by Ubly outlet to Lake Saginaw.
   Lake Saginaw, discharge by Grand River outlet to Lake Chicago.
   Lake Chicago, discharge by Chicago outlet to Illinois River.
4. General recession of ice border.
   Lake Wayne, discharge by Syracuse outlet to Mohawk River.
   Lake Chicago, discharge by Chicago outlet to Illinois River.
   Lake Duluth, discharge by St. Croix outlet to Mississippi River.
5. Readvance of ice border.
   Lake Warren, discharge by Grand River outlet to Lake Chicago.
   Lake Chicago, discharge by Chicago outlet to Illinois River.
   Lake Duluth, discharge by St. Croix outlet to Mississippi River.
6. General recession of ice border.
   Lake Lundy, Elkton, Dana discharge by Syracuse outlet to Mohawk Valley.
   Lake Chicago, discharge by Chicago outlet to Illinois River.
   Lake Duluth, discharge by St. Croix outlet to Mississippi River.
7. General recession of ice border.
   Lake Iroquois, discharge by Mohawk outlet.
   Lake Erie, discharge by Niagara outlet to Lake Iroquois.
   Lake Algonquin, discharge by (a) Trent outlet to Lake Iroquois.
   (b) By St. Clair outlet to Lake Erie.
   Lake Agassiz, discharge by River Warren to Mississippi River.
8. Ice border north of Great Lakes watershed.
   Lake Nipissing, discharge by (a) Ottawa outlet to Champlain Sea.
   (b) Part discharge by St.Clair outlet to Lake Erie.
   (c) Full discharge by St. Clair outlet
   Lake Erie, discharge by Niagara outlet to Lake Ontario or Champlain Sea.
   Champlain Sea in St. Lawrence valley.
   Close of Lake Agassiz, probably eastward discharge to Lake Algonquin followed by northeastward drainage to Hudson Bay.
9. Modern lakes discharging by St. Lawrence River.

R. W. Richards, *Secretary.*

The 266th meeting was held in the lecture room of the Cosmos Club, February 26, 1913, and the following informal communication was presented:

*Asphalt in a basaltic amygdaloid from British Columbia:* Norman L. Bowen.

The formal communications were:

*The zinc-lead deposits of the Yellow Pine district, Nevada:* J. M. Hill. The Yellow Pine district is in the southwestern part of Clark County, Nevada, near the California line. The mines are located on both sides of the southern Spring Mountains over an area of nearly 400 square

miles. Jean, on the San Pedro, Los Angeles, and Salt Lake railroad is the principal shipping point. Goodsprings, 8 miles northwest of Jean with a population of 200 is the largest town.

The ore deposits are of zinc and lead and form very irregular replacements which usually occur in more or less crystalline upper Mississippian limestone. They are found thru a vertical range of 3000 feet and do not seem to be restricted to any particular member of the sedimentaries. The principal factors in the localization of the ore bodies appear to be the presence of joints and crushed zones which in general strike east and west or nearly north and south, and are in most places nearly vertical.

The zinc and lead ores are usually closely associated. The ratio of zinc to lead, however, is extremely variable even in the same ore body. In general, the lead content is higher in the upper part of the ore bodies.

The only sulphide mineral common to these ores is galena. Part is probably original but some is undoubtedly secondary. At one place in the Potosi mine a small body of sphalerite ore was found entirely surrounded by oxidized zinc ores. This ore is considered to represent the primary ore, but it may be enriched. The sphalerite is intergrown with calcite and a little galena, and is iron-bearing.

The ores now being mined in the district consist of white or red iron-stained smithsonite, with some cerussite, anglesite, and galena. Calamine is not abundant and where seen is usually developed in the latest open water-courses in the other ore. Hydrozincite is sometimes present in fairly large masses in the ore bodies near the surface and often shows as a white coating on the croppings.

It is thought that the present bodies of carbonate ores have resulted in part from alteration of sulphide ores in place and in part from a downward concentration of the metals by surface waters which followed the fractures in their movement towards ground-water level.

*Pre-Wisconsin drift in the region of the Glacier National Park, Montana:* W. C. ALDEN and EUGENE STEBINGER. An abstract of this paper was published in the preliminary list of papers for the New Haven meeting of the Geological Society of America. The full paper is to be published in vol. 24 of the Bulletin of the Society.

FRANK L. HESS, *Secretary.*

## THE SEMI-CENTENARY ANNIVERSARY OF THE NATIONAL ACADEMY OF SCIENCES

The National Academy of Sciences will celebrate the 50th anniversary of its foundation at the National Museum in Washington April 22–24 inclusive. The program will include the following addresses, to which the members of the Washington Academy of Sciences and of its affiliated societies are cordially invited.

Tuesday, April 22.—Opening session, 11 a.m. Welcome by President IRA REMSEN.

*The relation of science to higher education in America:* President ARTHUR T. HADLEY, of Yale.

*International coöperation in research:* Prof. ARTHUR SCHUSTER, Secretary of the Royal Society.

Afternoon session, 3 p.m.—*The earth and sun as magnets:* Dr. GEORGE E. HALE, Director of the Mount Wilson Solar Observatory.

Wednesday, April 23, 10.30 a.m.—*On the material basis of heredity:* Prof. THEODOR BOVERI of the University of Würzburg.

*The structure of the universe:* Prof. J. C. KAPTEYN of the University of Groningen.

All addresses will be in English.

THE PROCEEDINGS

OF THE

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VOL. III. MAY 4, 1913. No. 9.

# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES



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# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES

Vol. III MAY 4, 1913 No. 9


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VITAL STATISTICS.—*A natural population norm.*[1] I. Alfred J. Lotka. Communicated by G. K. Burgess.

Birthrate and deathrate are in general functions of the age-distribution in a given population. Hence, for purposes of comparison, it is customary to "correct," the "crude" death rates to correspond to some arbitrarily chosen "standard population."

The age distribution itself is not, however, purely fortuitous, but tends to approach a certain "stable" type, as has been shown by the writer elsewhere.[2]

Instead, therefore, of studying conditions in an arbitrary standard population, it seems worth while to study the characteristics of a "natural population norm," in which the stable age-distribution is actually established. This is the purpose of the present paper. At the same time we shall compare the results obtained for such an "ideal" population norm, with figures actually observed in a case which approaches very nearly the calculated "normal" conditions.

I. *Birthrate, deathrate and age-distribution in life.* As the basis of our present discussion we shall use the formulae developed on a previous occasion, which are as follows.

[1] Paper read before the Philosophical Society of Washington on February 1, 1913.

[2] Am. Jl. Sc. **24**: 199, 375. 1907. Science **26**: 21. 1907. Phil. Mag., p. 435. April 1911. Compare also Bristowe, St. Thomas's Hospital Report, 1876, as quoted in A. Newsholme, Vital Statistics, p. 295. 1899.

$$c(a) = be^{-ra}\,p(a) \tag{1}$$

$$b = \frac{1}{\int_0^{\infty} e^{-ra}\,p(a)\,da} \tag{2}$$

$$d = -b\int_0^{\infty} e^{-ra}\,\dot{p}(a)\,da \tag{3}$$

TABLE I

MALES

| $a_1\ a_2$ | $A'_0$ | $A'_1$ | $A'_2$ | $A'_3$ | $A'_4$ | $A'_5$ | $A'_6$ |
|---|---|---|---|---|---|---|---|
| 0– 5 | 4.009 | 9 | 25 | 40 | | | |
| 5–10 | 3.598 | 28 | 110 | 330 | | | |
| 10–15 | 3.512 | 44 | 280 | 1280 | $0.01 \times 10^6$ | | |
| 15–20 | 3.444 | 60 | 535 | 3250 | 0.02 | | |
| 20–25 | 3.344 | 76 | 855 | 6540 | 0.04 | $0.02 \times 10^7$ | |
| 25–35 | 6.295 | 188 | 2860 | 28170 | 0.24 | 0.16 | |
| 35–45 | 5.622 | 224 | 4580 | 59330 | 0.63 | 0.53 | $0.04 \times 10^9$ |
| 45–55 | 4.758 | 238 | 5900 | 98670 | 1.26 | 1.29 | 0.11 |
| 55–65 | 3.636 | 217 | 6520 | 128000 | 1.92 | 2.33 | 0.24 |
| 65–75 | 2.217 | 154 | 5300 | 126000 | 2.20 | 3.04 | 0.35 |
| 75–∞ | 0.918 | 74 | 3000 | 78670 | 1.58 | 2.62 | 0.34 |
| $\Sigma A' = A$ | 41.353 | 1312 | 29965 | 530280 | $7.90 \times 10^6$ | $9.99 \times 10^7$ | $1.08 \times 10^9$ |

FEMALES

| $a_1\ a_2$ | $A'_0$ | $A'_1$ | $A'_2$ | $A'_3$ | $A'_4$ | $A'_5$ | $A'_6$ |
|---|---|---|---|---|---|---|---|
| 0– 5 | 4.142 | 10 | 25 | 40 | | | |
| 5–10 | 3.744 | 28 | 115 | 300 | | | |
| 10–15 | 3.657 | 46 | 295 | 1300 | | | |
| 15–20 | 3.585 | 63 | 560 | 3300 | $0.02 \times 10^6$ | | |
| 20–25 | 3.483 | 78 | 780 | 6900 | 0.04 | | |
| 25–35 | 6.579 | 196 | 2995 | 30700 | 0.24 | $0.02 \times 10^8$ | |
| 35–45 | 5.956 | 230 | 4760 | 64300 | 0.65 | 0.05 | p.04 $\times 10^9$ |
| 45–55 | 5.203 | 264 | 6480 | 108700 | 1.37 | 0.14 | 0.12 |
| 55–65 | 4.208 | 252 | 7560 | 150700 | 2.26 | 0.27 | 0.28 |
| 65–75 | 2.759 | 192 | 6700 | 154700 | 2.72 | 0.38 | 0.44 |
| 75–∞ | 1.309 | 108 | 4200 | 114700 | 2.32 | 0.38 | 0.52 |
| $\Sigma A' = A$ | 44.62 | 1467 | 34470 | 635700 | $9.62 \times 10^6$ | $1.24 \times 10^8$ | $1.40 \times 10^9$ |

In these formulae $b$ is the birthrate per head per annum, $d$ the corresponding deathrate, $r$ is the "natural rate of increase" of the population, i.e., $r = b - d$; $p(a)$ is the probability at birth that a given individual picked at random (at birth) shall reach age $a$, and is the function tabulated in the so-called life tables, where it is commonly denoted $l_x$; $\dot{p}(a)$ is the derivative of $p(a)$ with regard to $a$. Lastly, $c(a)$ is the coefficient of age-distribution, which is

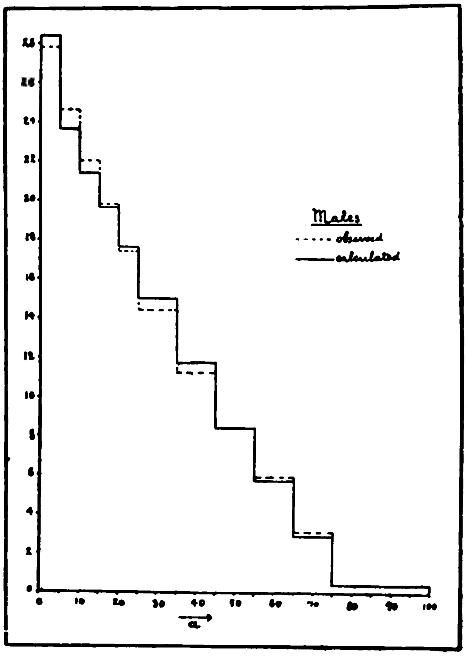


**Fig. 1. Age-distribution in the living population, England and Wales 1871–1880. Areas represent numbers of persons. Males.**

so defined, that, out of the total number $N$ of the population, the number comprised between the age-limits $a$ and $(a + da)$ is given by $Nc(a)da$.

Now the formulae, as given above, are not in the form best adapted for certain numerical computations. They were therefore developed in series by expanding the exponential function

under the integral sign, and integrating term by term. We thus obtain expressions of the form

$$\frac{1}{b} = A_0 - A_1 r + A_2 r^2 - A_3 r^3 + \cdots \tag{4}$$

TABLE II[3]

AGE—DISTRIBUTION

| $a_1$ $a_2$ | MALES | | FEMALES | | PERSONS | |
|---|---|---|---|---|---|---|
| | Calculated | Observed | Calculated | Observed | Calculated | Observed |
| 0– 5 | 142 | 139 | 135 | 132 | 138 | 136 |
| 5–10 | 118 | 123 | 114 | 117 | 116 | 120 |
| 10–15 | 107 | 110 | 104 | 104 | 106 | 107 |
| 15–20 | 98 | 99 | 95 | 95 | 96 | 97 |
| 20–25 | 88 | 87 | 86 | 91 | 87 | 89 |
| 25–35 | 150 | 144 | 148 | 149 | 149 | 147 |
| 35–45 | 117 | 112 | 117 | 115 | 117 | 113 |
| 45–55 | 84 | 84 | 87 | 87 | 86 | 86 |
| 55–65 | 57 | 59 | 63 | 61 | 60 | 59 |
| 65–75 | 29 | 31 | 36 | 35 | 32 | 33 |
| 75–∞ | 11 | 12 | 13 | 15 | 12 | 13 |
| | 1001 | 1000 | 998 | 1001 | 999 | 1001 |

TABLE III

| | MALES | | FEMALES | | PERSONS | |
|---|---|---|---|---|---|---|
| | Calculated | Observed | Calculated | Observed | Calculated | Observed |
| Birthrate per head : $b$.. | 0.03647 | 0.03692 | 0.03374 | 0.03372 | 0.03508 | 0.03528 |
| Deathrate per head: $d$. | 0.02216 | 0.02261 | 0.02001 | 0.01999 | 0.02107 | 0.02127 |
| Excess : $(b–d) = r$...... | (0.01431) | 0.01431 | (0.01373) | 0.01373 | (0.01401) | 0.01401 |
| Proportion of females to males............... | 1.045 | 1.055 | | | | |

[3] The figures given in this table differ somewhat from those published in Phil. Mag., loc. cit.; the latter were computed directly from formula (1), using for $r$ the mean value 0.01401 for the mixed sexes; in computing the results given in the present paper the different values of $r$ for males and females were taken into account, as indicated in Table III.

TABLE IV

| b | h | d | r |
|---|---|---|---|
| 0.040 | 0.01582 | 0.02197 | 0.01803 |
| 0.038 | 0.01382 | 0.02205 | 0.01595 |
| 0.036 | 0.01182 | 0.02217 | 0.01383 |
| 0.034 | 0.00982 | 0.02234 | 0.01166 |
| 0.032 | 0.00782 | 0.02256 | 0.00944 |
| 0.030 | 0.00582 | 0.02284 | 0.00716 |
| 0.028 | 0.00382 | 0.02322 | 0.00478 |
| 0.026 | 0.00182 | 0.02368 | 0.00232 |
| 0.024 | −0.00018 | 0.02423 | −0.00023 |
| 0.020 | −0.00418 | 0.02574 | −0.00574 |
| 0.016 | −0.00818 | 0.02796 | −0.01196 |
| 0.012 | −0.01218 | 0.03125 | −0.01925 |
| 0.008 | −0.01618 | 0.03603 | −0.02803 |

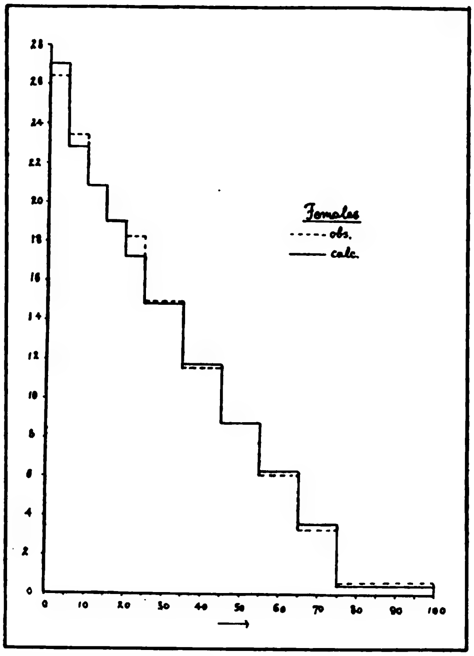


Fig. 2. Age-Distribution in the living population, England and Wales 1871–1880. Areas represent numbers of persons. Females.

and, for the fraction of the population comprised between the ages $a_1$ and $a_2$.

$$\int_{a_2}^{a_1} c\,(a)\,da = b\,(A'_0 - A'_1 r + A'_2 r^2 - A'_3 r^3 + \cdots) \qquad (5)$$

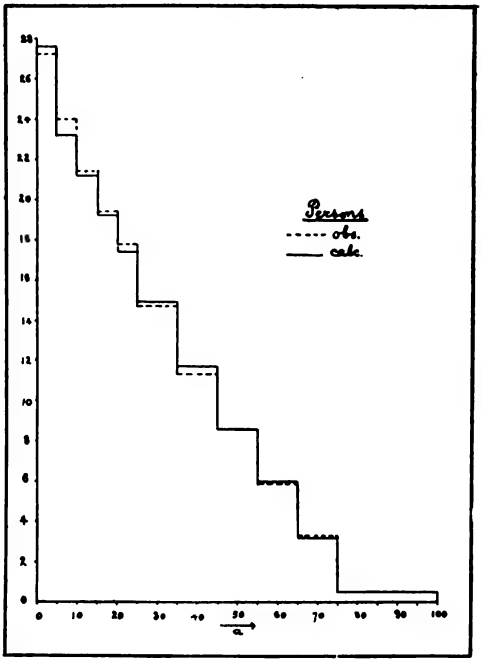


Fig. 3. Age-Distribution in the living population, England and Wales 1871–1880. Areas represent numbers of persons. Both Sexes.

In these series the constant coefficients are given by

$$A_n = \frac{1}{n\,!}\int_0^{\infty} a^n\,p\,(a)\,da \qquad (6)$$

$$A'_n = \frac{1}{n\,!}\int_{a_1}^{a_2} a^n\,p\,(a)\,da \qquad (7)$$

The value of the constants $A$, $A'$ can be determined in a given numerical example by graphic integration. Using the data given in the Supplement to the Forty-Fifth Annual Report of the Registrar-General of Births, etc., in England, covering the decen-

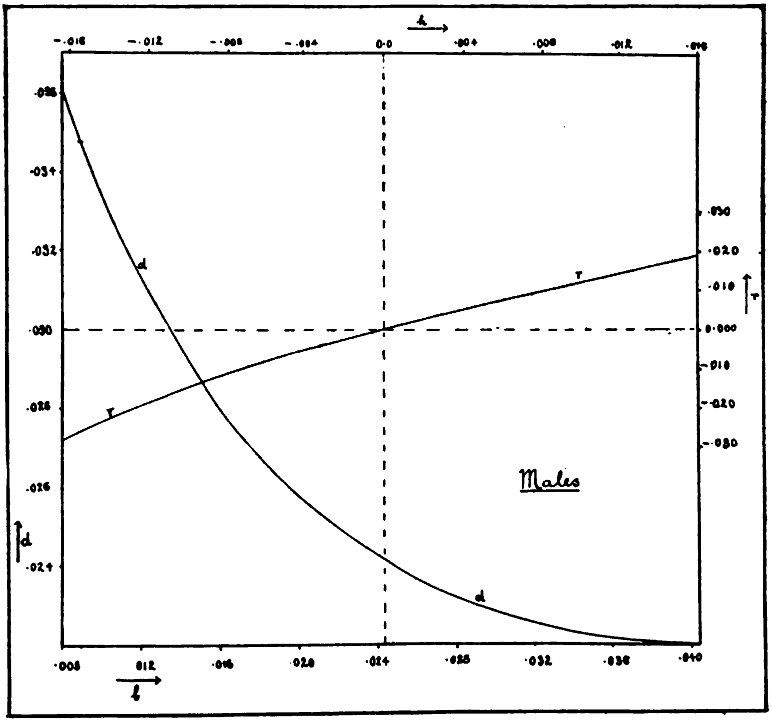


Fig. 4. Relation between birthrate per head $b$, deathrate per head $d$ and natural rate of increase $r$ in a population with stable age-distribution (on the basis of statistics for England and Wales 1871–1880).

nium 1871–1880, the numerical values shown in Table I were obtained, partly by the aid of the planimeter and partly by application of Simpson's Rule.

Using the values of the constants thus obtained, and substituting for $r$ the observed values, as given in the source cited above,

the results shown in Tables II and III were found. These results are also shown in graphic representation in figures 1, 2 and 3. It will be seen that there is a remarkably close agreement between observed and calculated values.

In order to obtain an idea of the general character of the function defined by equations (2), (4) and Table I, the values of $b$ corresponding to a number of values of $r$ were computed[4] and a curve was plotted. The numbers so obtained are shown in Table IV, and the curve in figure 4, It should be remarked that the portion of the curve corresponding to high negative values of $r$ is of course only of geometrical interest—in nature such a value could only occur under exceptional circumstances, and then only for a limited time, as it would lead, in practise, to the extinction of the species.

[4] To be more precise, the computation was performed by the aid of another series derived from (4). By (4) and Table I we have

$$\frac{1}{b_m} = 41.35 - 1312r + 29960r^2 - 530300r^3 + 7.9 \times 10^6 r^4 - 9.99 \times 10^7 r^5 + 1.08 \times 10^9 r^6 - \ldots$$

This gives

$$b_m = 0.02418 + 0.7673r + 6.823r^2 - 29.32r^3 - 651.3r^4 - \quad . \quad . \quad .$$

When $r = 0$, $b = b_0 = d_0 = 0.02418$. Putting $h = b - b_0$ and reverting the series by the method given by Prof. J. McMahon (Bull. Am. Math. Soc., April 1894, p. 170; see also C. E. Van Orstrand, Phil. Mag., March, 1910, p. 366) we have:

$$r = 1.3033h - 15.10h^2 + 434.6h^3 - 12590h^4 + 26500h^5 - \quad . \quad . \quad .$$

and finally, since $r = (b - d)$,

$$d = 0.02418 - 0.3033h + 15.10h^2 - 434.6h^3 + 12590h^4 - 265000h^5 + \quad . \quad . \quad .$$

The actual computation was carried out by means of this last series. The rapidity of the convergence of the series above is indicated by the number of terms given, which is each case represents an accuracy of four significant figures in the result, when $r$ has a value of about 0.01400.

CHEMISTRY.—*The determination of phosphorus in steels containing vanadium.* J. R. CAIN and F. H. TUTTLE. To appear as a Technologic Paper of the Bureau of Standards. Communicated by W. F. Hillebrand.

In order to precipitate phosphorus quantitatively as phosphomolybdate from steels containing vanadium, it is necessary to reduce the latter to the quadrivalent state, otherwise precipitation is incomplete and there is contamination of the phosphomolybdate by vanadium. In the present method ferrous sulphate in slight excess is used as the reducing agent and the following conditions should be observed: (1) The temperature of precipitation should be held at a point (15° to 20°) where the nitric acid does not oxidize the excess of ferrous salt or the reduced vanadium before complete precipitation of phosphorus takes place; (2) the partial neutralization with ammonia, frequently used when phosphorus is precipitated as phosphomolybdate, must be made before reduction of the vanadic acid, otherwise the heat of neutralization causes the oxidation of most of the ferrous iron and reduced vanadium by the nitric acid: (3) care must be taken to prevent the action of oxides of nitrogen, formed by interaction of ferrous salt and nitric acid, on the reduced vanadium since these substances seem to catalyze the oxidation of the vanadyl salt and may in some cases completely prevent precipitation of phosphorus, owing to the large amount of vanadic acid produced; (4) efficient means for shaking or agitation of the solutions in which precipitation is to take place must be provided.

MINERALOGY.—*The refractive indices of strengite.* WALDEMAR T. SCHALLER, Geological Survey.

The only published values for the refractive indices of strengite, $Fe_2O_3.P_2O_5.4H_2O$, which I have been able to find are those given by Schroeder van der Kolk,[1] namely 1.81 + 0.03; Lacroix[2] has stated them in the form: $\alpha = 1.81$, $\gamma = 1.84$. Determination of these values for a manganese strengite from California[3] gave

[1] Tabellen Mikrosk. Bestimmung d. Mineralien, p. 54, 1906.

[2] Mineralogie de la France **4**: 475, 1910.

[3] This Journal **2**: 145, 1912.

the values: $\alpha$ = 1.70–1.71, $\gamma$ = 1.72–1.73. Lacroix[4] determined the mean index of similar material (called angelardite by him), as approximately 1.70. It therefore seemed necessary to redetermine the refractive indices of typical strengite in order to bring the conflicting determinations in accord.

Professor Ledroit of Mainz very kindly presented me with several specimens of the mineral from the Eleonore mine on the Dünsberg, near Giessen. The strengite forms small spherulites associated with beraunite (eleonorite), cacoxenite, etc. Crushed fragments of these spherulites were used for determining the minimum and maximum refractive indices. The oil immersion method was used and the values obtained are:

$$\alpha \text{ (normal elongation of fibers)} = 1.71$$
$$\gamma \text{ (parallel elongation of fibers)} = 1.735$$
$$(\gamma - \alpha) = 0.025$$

The values given by Schroeder van der Kolk are therefore wrong and it seems probable that his figure 1.81 was miscopied for 1.71.

[4]Mineralogie de la France **4**: 523, 1910.

## ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

METALLOGRAPHY.—*Metallographic testing.* Bureau of Standards Circular No. 42, 1913 (in press).

The circular considers metallography in its wider sense and does not restrict it to the microscopical analysis alone. Thermal analysis, together with the correlation of physical properties with microscopical structure, thus find their place here.

The different methods of thermal analysis are briefly reviewed and compared. The importance that is attached to the metallographic method in the iron and steel industry is illustrated by a partial list of the more common applications in that field.

The tests that the Bureau of Standards is equipped at present for carrying out are:

1. *Thermal.* Cooling and heating curves, melting points, heat treatment of alloys as specified.

2. *Microscopical.* Preparation of specimens and photomicrographs of specified magnification up to 1000 diameters (higher magnification by special arrangement), microscopical examination after special heat treatment.

3. *Miscellaneous.* Examination of metals after failure for evidence of the cause of failure, determination of various physical constants of metals and their temperature coefficients. H. S. Rawdon.

BIOLOGICAL CHEMISTRY.—*A biochemical study of the curly-top of sugar beet.* H. H. Bunzel, U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 277. 1913.

Oxidase determinations were made on healthy and diseased sugar beets growing under different conditions at Utah in the summer of 1911. The experiments were carried out on the roots, leaves, and other parts of the plants separately, according to the method described in Bulletin

238 of the Bureau of Plant Industry. The determinations show that the oxidase content of the leaves is abnormally high wherever the growth of the plants has been retarded, whether such retardation of growth is due to the curly-top disease, to excessive watering, to drought, or to unknown abnormal conditions of plant growth. Studies made on the distribution of the oxidases of different parts of the plant show that the seeds are highest in oxidase content, the leaves follow, the roots are almost as active as the leaves, while the stems show a lesser activity.

Determinations of moisture, total nitrogen, ash, and sugar in the alcohol-soluble and alcohol-insoluble fractions of the roots and leaves show no differences between the healthy and diseased material. It is suggested that indications point toward the diseased plants being in a state analagous to "fever." H. H. B.

BIOLOGICAL CHEMISTRY.—*Biochemical factors in soils.* M. X. SULLIVAN. Bureau of Soils. Eighth International Congress of Applied Chemistry, **15**: 305. 1912.

The soil possesses oxidizing and catalyzing powers which are stronger in the more productive soils and are more manifest in soils than in subsoils. There are evidences of enzyme action in soils but as yet no good method has been obtained for extracting enzymes from soil. Many of the substances found in soil undoubtedly arise to a considerable degree as a result of the metabolism of microorganisms. In mold cultures have been found fatty acids, especially oleic and palmitic, purine bases, such as guanine, adenine and hypoxathine, histidine and probably thymine. In the solution in which molds have grown were found fatty bodies, guanine, adenine, hypoxathine, histidine, and probably thymine. M. X. S.

AGRICULTURAL CHEMISTRY.—*Normal and abnormal constituents of soil organic matter.* E. C. LATHROP. Eighth International Congress of Applied Chemistry, **15**; 147–151. 1912.

Pentosans, pentose sugars, histidine, xanthine, hypoxanthine, cytosine and possibly creatinine may be considered to be normal soil constituents. Arginine and adenine on account of their infrequent occurrence and their rapid disappearance, and dihydroxystearic acid and picoline carboxylic acid on account of their detrimental action on plant growth, and the striking relation of the former to infertility, must be classed as abnormal soil constituents. Regarding agroceric acid, lignoceric acid, paraffinic acid, and $\alpha$mono-hydroxystearic acid, agrosterol and hentriacontane no statement is warranted. E. C. L.

AGRICULTURAL CHEMISTRY.—*Effect of histidine and arginine as soil constituents.* J. J. SKINNER. Eighth International Congress of Applied Chemistry, **15**: 253. 1912.

In this article attention is directed to the occurrence and distribution of histidine and arginine in soils. The effect of each on plant growth was tested in nutrient culture solution and both were found to be beneficial. Plants growing in culture solutions containing only potash and phosphate showed greatly increased growth when histidine or arginine is added. When large amounts of nitrate are present in the culture solution, histidine and arginine produce no appreciable effect on the growth. Plants growing in cultures, whether high or low in nitrate, showed a greatly diminished absorption of nitrate when histidine or arginine was present, whereas the removal of potash and phosphate was practically normal. It appears, therefore, that histidine and arginine, like creatinine, creatine, asparagine, and a number of other nitrogenous compounds can replace the effect of nitrate in producing plant growth. J. J. S.

AGRICULTURAL CHEMISTRY.—*Guanine from a heated soil.* E. C. LATHROP. Journal of the American Chemical Society, **34**: 1260. 1912.

In the course of an investigation on the chemical changes in soil organic matter brought about by heating soil in an antoclave for three hours at 30 pounds pressure, guanine was isolated and identified. The guanine was not found in the unheated soil and arises from the breaking down by heat of higher forms of nitrogenous material, probably nucleic acid. E. C. L.

AGRICULTURAL CHEMISTRY.—*Influence of phosphate on the toxic action of cumarin.* J. J. SKINNER. Botanical Gazette, **54**: 245. 1912.

The toxic action of cumarin to wheat seedlings, and the action of phosphates in ameliorating the toxicity, was studied by growing the plants in nutrient culture solutions. It was found that calcium acid phosphate, mono-sodium phosphate, di-sodium phosphate and tri-sodium phosphate, had a similar effect in overcoming the harmful effect of the cumarin. Calcium and sodium phosphate, the latter under different conditions, acid, neutral and alkaline, had the same effect. The effect of the phosphate salts in ameliorating the harmful action of cumarin is due, therefore, to the phosphate radical, and not to the calcium or sodium or to an acid or alkaline condition. J. J. S.

AGRICULTURAL CHEMISTRY.—*City street sweepings as a fertilizer.* J. J. SKINNER and J. H. BEATTIE. Circular of the Bureau of soils, No. 66. 1912.

Several samples of street sweepings from one of the large cities were analyzed and found to contain slightly less phosphate, nitrate and potash than the average stable manure. The effect of the sweepings on growth was tested, by growing corn, wheat and cabbage in paraffined wire pats. The street sweepings produced increased growth, but were not as effective as stable manure. The sweepings were analyzed for mineral oil and some of the samples contained as much as 2 per cent. The oil isolated from the sweepings was tested and found to be harmful to growth. After the oil had been extracted, the street sweepings were as efficient in producing growth as stable manure. J. J. S.

AGRICULTURAL CHEMISTRY.—*Lawn soils and lawns.* OSWALD SCHREINER, J. J. SKINNER, L. C. CORBETT and F. L. MULFORD. Farmers' Bulletin, U. S. Department of Agriculture, No. 494. 1912.

In this bulletin is presented the character of soils in respect to their suitability for lawn making. The texture of soils as related to lawns is emphasized. The soils suitable for the building of lawns, parks, parked embankments, terraces, etc., receive special consideration; also the best methods for building up artificial grounds by the hauling in of such suitable soil material, both for subsoil fillings and for surface layering. A list of soil types well adapted to grass growing is included.

The establishment, fertilization and maintenance of lawns are considered and suggestions given as to the selection of seeds adapted to lawn making. A chapter on the relation of walks, drives, trees and shrubs to the lawn is included. J. J. S.

AGRICULTURAL CHEMISTRY.—*Beneficial effect of creatinine and creatine on growth.* J. J. SKINNER. Botanical Gazette, **54**: 152. 1912.

Creatinine and creatine are both beneficial to plant growth. Plants growing in culture solutions containing only potash and phosphate show increased growth when creatinine or creatine is added. When large amounts of nitrates are present in the solution, creatinine and creatine produce no appreciable effect on the growth. In the presence of these compounds the plants absorb less nitrate, while the absorption of potash and phosphate is normal. It appears that creatinine and creatine can replace nitrate in solution cultures. J. J. S.

AGRICULTURAL CHEMISTRY.—*Effect of asparagin on absorption and growth in wheat.* J. J. SKINNER and J. H. BEATTIE. Bulletin Torrey Botanical Club, **39**: 429. 1912.

Wheat seedlings were grown in nutrient solutions of phosphate, potash, and nitrate in varying proportions and to these were added 50 p.p.m. of asparagin. Asparagine had a beneficial effect on plant growth. When large amounts of nitrate were present in the culture solutions asparagin produced no appreciable effect on growth. The plants absorbed less nitrate from the culture solution while the phosphate and potash absorption was normal. While the effect of the asparagin on plant growth decreased with increasing nitrate, it had nevertheless a conserving effect upon the amount of nitrate left in the solution. It appears therefore that the plant can utilize this nitrogenous compound for plant synthesis. J. J. S.

AGRICULTURAL CHEMISTRY.—*Manganese as a fertilizer.* M. X. SULLIVAN and W. O. ROBINSON. Circular of the Bureau of Soils, No. 75. 1912.

In this circular it is pointed out that fertilizing with manganese has led to varying results. The general conclusion is drawn that in view of the complexity of the soil and the discrepancy that has been found in the use of manganese fertilizers, manganese cannot be recommended in any way other than in experimentation and as a fertilizer complementary to the usual chemical fertilizers, nitrate, phosphoric acid, potash and lime. M. X. S.

AGRICULTURAL CHEMISTRY.—*Studies in soil catalysis.* M. X. SULLIVAN and F. R. REID. Bulletin of the Bureau of Soils, No. 86. 1912.

Soils possess the power to decompose hydrogen peroxide. This power is greater in soil than in subsoils, in strong vital soils than in weak soils. It persists for years in air-dried soils.

Tho good production is not dependent on the catalytic power, the presence of a strong catalytic power in a soil can be taken as *a priori* evidence that the many factors making for soil fertility would be prominent and that the soil would be a productive soil. The catalytic power is checked to some degree by carbon bisulphide, mercuric chloride and especially by hydrocyanic acid, which in some cases practically destroys it. Heating in an autoclave under pressure of 10 atmospheres retards the catalytic power, tho dry heat for one hour at

105° has little depressing action. Various inorganic substances and several organic compounds, especially those in a state of partial oxidation, have the power of decomposing hydrogen peroxide, while several organic compounds increase the catalytic power of manganese dioxide.

In general the catalytic power of soils seems to be due not to an enzyme, such as catalase, but rather to the inorganic and organic matter working separately, conjointly, or in activating combination.

M. X. S.

AGRICULTURAL CHEMISTRY.—*Some organic soil constituents.* E. C. SHOREY. Bulletin of the Bureau of Soils, No. 88. 1912.

The isolation of 15 organic compounds is described, 14 of which have been identified. These together with those previously isolated and described make 35 organic compounds isolated from soils. The substances here described belong to six classes of organic compounds, three of which, aldehydes, organic sulfur, and organic phosphorus compounds are classes not represented among those isolated and described before.

The compounds isolated have been classified as follows: 13 organic acids, 9 organic bases, 3 sugars, 2 aldehydes, 2 alcohols, and 1 each, hydrocarbon, glyceride, resin ester, sulfur compound, phosphorus compound and an acid anhydride. The relationship between these groups as well as that between the isolated compounds and the organic matter in general is discussed. The compounds isolated and described here are oxalic acid, succinic acid, saccharic acid, acrylic acid, lysine, adenine, choline, trimethylamine, salicylic aldehyde, mannite, rhamnose, trithiobenzaldehyde, nucleic acid, of unknown constitution, and an unidentified aldehyde.

The conclusion is reached that the work, like that previously reported, while it emphasizes the complex character of the organic matter of soils, bears out the contention that this complexity is not so great but that the chemical nature of all of the organic matter of soils can be determined by modern methods of research. M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*The chemistry of steam-heated soils.* OSWALD SCHREINER and ELBERT C. LATHROP. Bulletin of the Bureau of Soils, No. 89. 1912.

This bulletin deals with the chemical changes involved when soils are steam heated, as in the process of sterilization. The results may be summarized as follows: (1) In accord with the work of other inves-

tigators it was found that there was an increase in water-soluble constituents and an increase in acidity. At the same time ammonia and amines were formed. (2) By the process of heating there were formed xanthine, hypoxanthine, guanine, cytosine, and arginine, when not previously existing. These compounds are decomposition products of nucleic acid and protein material and are all beneficial to plant growth. (3) Guanine is reported for the first time as a constituent of soil organic matter. (4) Dihydroxystearic acid was increased when present, and produced, when not previously present, by the heating process. This compound is harmful to plant growth. (5) Both beneficial and harmful compounds were produced by heating the soils and were isolated. This bears out the experience of previous investigators with cultural tests. (6) Cultural tests in these soils and their extracts showed that the heated soils gave a poorer plant growth. (7) Although the majority of compounds formed must be classed as beneficial, the harmful compound formed at the same time more than overbalances their effects. Not until this harmful compound is eliminated or diminished can the full beneficial effects of heating be demonstrated. (8) In soils there is a balance of beneficial and harmful factors, soil fertility or infertility being the resultant of the two groups. As one or the other group of factors gains the ascendency, the fertility is raised or lowered, as the case may be. This balance is influenced by cultural treatment, fertilizers, liming, crop growth, or crop rotation, etc., as well as by steaming. (9) The results show that altho the soils studied have received the same kind of organic matter and have received the same form treatment, they have been subject to different biochemical factors, resulting in differences in their organic matter and in differences in their fertility. E. C. L.

INDUSTRIAL CHEMISTRY.—*The effect of certain pigments on linseed oil with a note on manganese content of raw linseed oil.* E. W. Boughton. Circular of the Bureau of Chemistry No. 111. 1913.

Raw linseed oil was mixed with different pigments so that the paint thus prepared had a consistency similar to that of ordinary mixed paint, ready for use. The containers were air tight and the paints were kept for two years. Samples of the oil from each paint were withdrawn at the end of one and of two years, and the constants thereof determined. The raw oil had a specific gravity of 0.934 (15.6/15/6°C.). The greatest increase (to 0.940) was caused by white lead (basic carbonate). Flake graphite, zinc oxide and zinc chromate had no appreciable effect.

The iodine number of the raw oil was 179.6. The greatest decrease (to 171.6) was caused by kaolin. Flake graphite, artificial graphite, zinc chromate, zinc oxide, and chromium oxide had practically no effect, and basic carbonate of lead, Indian red, magnetic black, and lead chromate had but a very slight effect. The percentage of ash in the raw oil (0.13 per cent) was raised to 0.40 per cent by the basic carbonate of lead. The increases due to the other pigments were but slight. Basic carbonate of lead, kaolin, and lead chromate bleached the oil. The results as a whole show surprisingly small changes due to the pigments. At the end of two years the results obtained were practically the same as those obtained at the end of one year. In no case was the iodine number lowered to a figure below that given by pure raw oil from South American seed (171). The percentage of manganese in sixteen samples of raw linseed oil of known purity and source varied from a faint trace (less than 0.0002 per cent) to 0.0008 per cent.

E. W. B.

GEOLOGY.—*The Eagle River region, southeastern Alaska.* Adolf Knopf. Bulletin U. S. Geological Survey No. 502. Pp. 61, with maps, sections, and illustrations. 1912.

The Eagle River region, includes the northern portion of the Juneau gold belt, extending northwestward from Salmon Creek, near Juneau, to Berners Bay. This strip of territory is 32 miles long and embraces approximately a third of the entire length of the gold belt.

The rocks are arranged in belts that strike parallel to the general trend of the gold belt and dip steeply northeast. The general parallelism of stratification, cleavage, schistosity, gneissic foliation, dikes, and ore bodies is the salient geologic feature of the region.

The larger part of the gold belt is underlain by an interstratified series of slates and graywackes, with some conglomerates. This assemblage of sedimentary rocks, together with intercalated masses of volcanic rocks, has been named the Berners formation. Fossil plants, consisting chiefly of ferns, indicate that it is of Jurassic or Lower Cretaceous age.

The volcanic rocks, associated with the slates and graywackes consist of lavas, flow breccias, tuffs and coarse breccias, conglomerates, and various kinds of mixed rocks. The clastic material far exceeds the massive rock in bulk. The lavas are in many places extremely amygdaloidal and locally display a striking ellipsoidal structure. They are characterized by the widespread prevalence of numerous well-formed and well-preserved phenocrysts of augite embedded in a dense-grained matrix of

dark blue-green color, and to signalize this feature they are termed augite melaphyres.

Toward the northeast the slates and graywackes pass gradually into phyllites and schists, which become progressively more and more crystalline toward the diorite gneiss that forms the northeast boundary of the gold belt. The schists where they adjoin the gneiss are garnetiferous, staurolitic, cyanitic, and coarsely biotitic.

The gneiss on the northeast, which in local usage is known as the granite hanging wall of the Juneau gold belt, is the crushed and foliated margin of the great intrusive quartz diorite core of the Coast Range. The gneissic structure is best developed near the contact with the schist and fades out northeastward into the ordinary structure of normal granitic rocks. It is essentially a cataclastic effect which was produced by the crushing of the component minerals of the quartz diorite, and which was impressed on the diorite soon after the diorite had consolidated from fusion. In fact, a period of dynamic deformation set in during the pegmatitic stage, for some of the pegmatite and aplite dikes are sheared like the gneiss, but others have escaped the general dynamic metamorphism. The sedimentary rocks adjoining the gneiss have recrystallized into schists, whose crystallinity, as already stated, diminishes gradually from the contact. The region thus affords a remarkably fine illustration of a belt of highly crystalline schists formed as an effect of the heat and pressure accompanying a great batholithic intrusion of late Mesozoic age.

The ore bodies are exclusively gold deposits. The great majority are stringer lodes, but include some mineralized dikes and a few fissure veins. Except for sporadic sheets of rich ore, the stringer lodes are of low grade. They range in width from a few feet to 100 feet, and apparently at a few prospects, to 300 to 400 feet. The greatest depth attained by mining anywhere in the district does not exceed 200 feet.

Some of the mineralized dikes are of economic importance; all are of considerable interest because the profound alteration which they have undergone throws light on the character of the solutions that brought in the gold. A common change consisted in a large introduction of soda and the formation of albite, and this albitization is here shown to be a regional feature of the Juneau gold belt. Other changes consisted in the introduction of apatite into the altered wall rocks and the conversion of amphibole into biotite. From these and other features the vein-forming waters are believed to have been hot, ascending solutions of deep-seated origin, probably connected with the intrusion of the diorite magma.

A. K.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE CHEMICAL SOCIETY

### (Local Section of the American Chemical Society)

The 222d meeting was held on January 31, 1913, at the Chamber of Commerce. Resolutions upon the death of Prof. J. W. Mallet, prepared by Professor Dunnington of the University of Virginia, were adopted by a rising vote. The following papers were read, all contributed by members of the Bureau of Soils:

*Problems in soil fertility:* Oswald Schreiner. The essential problem in soil study is that of infertility. Liebig's theory of impoverishment in chemical constituents as a cause of infertility was only temporarily useful, and chemical analysis proved inadequate in predicting fertility. Soil extracts were then found to reflect very closely the degree of fertility of soils, but this fertility did not depend upon the inorganic substances in solution. Finally the cause of infertility was traced to organic poisons in soils. Along with this change in the point of attack have come great changes in the laboratory equipment necessary for soil investigations.

*Recent work on the chemical composition of humus:* E. C. Shorey. The organic matter extracted from a soil, is separable into two fractions. From the portion of the organic matter soluble in 2 per cent sodium hydroxide about 35 pure organic compounds have been isolated, of which 11 are nitrogenous; 14 of these compounds are acids, and 10 bases. The portion precipitated by acids contains complex resins and other substances not yet separated. The author described 3 new compounds recently separated: (1) meta-oxytoluic acid, of which 5 grams were obtained from 50 pounds of soil; (2) vanillin, in very small quantity; (3) tetra-carbonimide, perhaps an intermediate compound in the oxidation of uric acid to urea.

*The origin of certain organic soil constituents:* M. X. Sullivan. Certain molds found in soils were separated in cultures, grown in considerable quantities on Rankine's solution, and studied chemically. Fatty acids (such as oleic, stearic, and palmitic), xanthin, hypoxanthine, mannite, thyurine, pentose sugar, and various other compounds were obtained from these molds. Purin bases and fatty acids were also found in the solution in which the molds were grown. The metabolism of molds and bacteria is an important source of the compounds found in humus. Certain compounds come from the disintegration of plant debris.

*Discussion:* In reply to inquiries, Dr. Sullivan stated that the relation between the quantity of the compounds described and the quantity

of food in the culture solution was not determinable; he considered that the abundance and variety of organic food in a soil rendered the results entirely independent of any consideration of the composition of the culture solution. The molds were grown in the absence of light.

*The physiological action of certain organic soil constituents:* J. J. SKINNER. Experiments were made on the effect of salicylic aldehyde, an organic soil constituent, upon the growth of wheat seedlings. Very dilute solutions reduced the growth markedly, or killed the plants. The effect is not neutralized by phosphates, nitrates, or potassium compounds. The metabolism of the plants is greatly retarded. Nucleic acid was found beneficial, the more so, the less nitrate was present. The compounds identified in soils have been classified into harmful and beneficial. Guanidin, picoline-carboxylic acid, vanillin, and dihydroxystearic acid are harmful, while nucleic acid, histidine, arginine, creatine, creatinine, etc. are beneficial.

Discussion by Schreiner, Cook, Hunt, Wells, Seidell, Waters, Cameron, Sullivan, and others. The principal points brought out were: The beneficial compounds seem to be absorbed unoxidized. Salicylic aldehyde was first found in soil from a rose garden at Mt. Vernon, where the soil was becoming unsatisfactory. The harmfulness of a compound can not be predicted from its composition or constitution. The experimental solutions all contain oxygen in solution. Lime and means for promoting oxidation act as a remedy for dihydroxystearic acid. Remedies for other poisons have not been worked out. The active poison in a given soil cannot be told from the appearance of plants grown in it. Flocculation of the soil, better drainage and promotion of oxidizing bacteria all aid in the oxidation of dihydroxystearic acid.

*Chemical changes in heated soils:* E. C. LATHROP. A fertile and infertile soil from the same locality were compared as to the effects produced by heating under 30 pounds steam pressure (135°). The water soluble constituents were increased. Beneficial compounds were formed, but the production of harmful constituents and the destruction of useful bacteria more than offset their effect. The net result was a decrease of fertility in the fertile soil. Dihydroxystearic acid was found before heating in the infertile soil, and after heating in both soils.

Discussion by Schreiner, Sullivan, Sosman, and Cameron.

The 223d meeting was held at the Cosmos Club February 13, 1913. The following papers were read:

*Tests for absinthe:* E. K. NELSON, of the Division of Drugs, Bureau of Chemistry. The various modifications of Legal's test for the detection of absinthe were found to give uncertain results in cases where the oil of wormwood was proportionately small in amount. By conversion of the ketones, including thujone from wormwood, into semi-carbazones, they can be freed by steam distillation from essential oils, such as anise, cloves, etc. The semi-carbazones are then decomposed with dilute acid, the ketones recovered, and Legal's test applied to the material thus purified. In presence of thujone the test is not only more delicate but the characteristic thujone odor can be detected. (Author's abstract.)

*Discussion:* Parsons inquired concerning the sharpness of legal definition necessary under the present law against absinthe. The author did not have exact data to furnish on this point.

*The analysis of certain Pacific coast kelps:* E. H. PARKER and J. R. LINDEMUTH, of the Bureau of Soils. Read by Mr. Parker. Specimens of the two most important kelps of the Pacific coast from an economic standpoint, as found by previous investigators, were collected from different points along the coast and analyzed for potash, soluble salts, nitrogen and iodine. The conclusions are: (1) the average KCl content is high; (2) Apparently no definite relation exists between the different constituents of kelp; (3) The average KCl content of the *Nereocystis luetkeana* is greater than that of the *Macrocystis pyrifera* this is true for kelp from different localities. In each single case, also, the KCl content of the Nereocystis is greater than the average of the Macrocystis; (4) Apparently the northern kelps are richer in KCl than the southern; (5) the iodine content of northern and southern kelps show no conclusive differences.

TABLE OF AVERAGES.

| SOURCE | KCL | IOD. | N. |
|---|---|---|---|
| | % | % | % |
| Freshwater Bay, Washington | 27.63 | | 2.14 |
| (Macrocystis) | 19.47 | | |
| (Nereocystis) | 29.54 | | |
| Coast between Los Angeles and San Francisco | 23.84 | | 2.21 |
| (Macrocystis) | 19.20 | | |
| (Nereocystis) | 31.74 | | |
| Coast near San Diego | 10.34 | | 1.11 |
| Total average | 21.85 | 0.20 | 1.93 |
| (Macrocystis) | 15.82 | | |
| (Nereocystis) | 30.50 | | |
| Average of all analyses of Pacific Coast kelps | 25.16 | | |

(Author's abstract.)

*Discussion:* In reply to inquiry, the author stated that the soluble ash formed about 3 per cent of the dry plant.

*The influence of environment upon the composition of wheat:* J. A. LECLERC and P. A. YODER of the Laboratory of Plant Chemistry, Bureau of Chemistry. Read by Dr. Yoder. The composition and physical properties of wheats have been shown by the Bureau of Chemistry to be dependent upon climate rather than upon heredity. The present investigation studied the effect of soils in comparison with climate, by interchange of blocks of soil, 5 feet square and 3 feet deep, between Maryland, Kansas, and California. The experiments have continued thru four years. The size of grain as well as other physical properties seem to depend chiefly upon the locality and very little on the soil. Results

on protein content are similar but there is a possible first-year effect of the soil. Gliadin number was very nearly the same in all. Other organic constituents varied irregularly. A more marked effect of soil is to be expected in the inorganic constituents, but the reverse seems to be true even in this case; for some constituents the effect of locality predominates, for others the data are uniform for all the samples. The effect on yield was not considered.

*Discussion.* M. X. Sullivan pointed out that varied treatment of the same soil in neighboring fields may cause wide variations in results. He further emphasized that a soil is like a living organism, and when transferred from one locality to another will itself change radically. Soil cannot therefore be considered a constant factor in comparative experiments such as these. Berger suggested that transfusion from the surrounding soil might rapidly affect the small blocks which were transferred, since they were not cut off entirely from surrounding soil. Cameron suggested that it is really the subsoil below 3 feet that contributes the soil solutions that feed the plant, and that this is the true explanation of the results obtained. LeClerc stated that the variations found in composition are much larger between localities than are ever found between differently treated samples of soil in a given locality. Franklin and Waters adduced other examples of the effect of environment as prevailing markedly over heredity. Yoder and Sullivan came to essential agreement that these experiments do not show how climate exerts its influence, and that the possibility is not excluded that the climate may react upon the soil in a way to influence the characteristics of the crop, thus exerting its effect in a measure thru the soil. Sosman, Cook, Tassin, and others also discussed the paper.

*Hydrogenation with colloidal palladium as catalyzer:* A. R. Albright, of the Division of Foods, Bureau of Chemistry. The great advantage of the palladium hydrogenation method lies in the low temperature and simple apparatus necessary. It has been found possible to attach hydrogen to double bonds which have usually been rather inaccessible to reduction. Many detailed examples were quoted of these reductions, which it is not possible to discuss in abstract.

*The rate of cooling in the green and its influence on the physical properties of annealed metals:* Wirt Tassin. It has been assumed widely that the properties of metal depend upon heat treatment (annealing) and its consequent changes in structure, rather than upon the conditions of casting. Hence the present widespread use of microscopic examination of specimens as a check upon properties. The author showed illustrations of a photomicrographic apparatus which he has developed for the examination of the casting itself. As a concrete example of its use, he showed numerous photomicrographs illustrating the effect of different rates of cooling "in the green," (i.e., in the casting fresh from the mold) both upon the initial properties of iron and steel castings, and upon their properties after the usual processes of annealing. The rate of cooling of the casting was shown to be a very important factor in the ultimate properties of the metal.

Robert B. Sosman, *Secretary.*

## THE BOTANICAL SOCIETY OF WASHINGTON

The 86th regular meeting was held at the Cosmos Club, February 4, 1913.

The following were elected to membership: Prof. R. Kent Beattie, Dr. Charles Brooks, Mr. J. G. Grossenbacher and Dr. Neil E. Stevens.

The following program was presented: Mr. T. H. Kearney: *Indicator value of natural vegetation in the Tooele Valley, Utah.* The Tooele Valley lies between the Oquirrh and Stansbury ranges and extends to the south shore of Great Salt Lake. It was found that the valley is occupied by some half dozen principal plant associations, each of which is characterized by the presence of one, or, at most, two dominant species of shrubs or perennial herbs. The presence of one or another association was found to be closely indicative of the moisture relations and salt content of the soil. The areas occupied by the different associations are often so sharply defined as to be recognizable at a distance of several miles

The presence of a good stand and growth of sage brush (*Artemisia. tridentata*) is always associated with a soil of rather light texture, very dry during the summer months, free from alkali salts, and with a low water table. This Artemisia association occupies mainly the higher lands of the valley. Descending the valley toward the shore of Great Salt Lake, successive zones are traversed which are occupied by the following associations: (2) *Kochia vestita*, (3) *Atriplex confertifolia* (Shadscale), (4) *Atriplex confertifolia* and *Sarcobatus vermiculatus* (Greasewood), (5) *Allenrolfea occidentalis*, (6) *Distichlis spicata* (Salt Grass) and two species of Salicornia.

Where associations 2 and 3 occur the soil is very dry during the summer, but has a higher moisture capacity than in the Artemisia association and the sub-soil is strongly saline. Under association 4 the soil becomes saline to the surface and the ground water table is relatively high. Associations 5 and 6 occupy the wet and highly saline soils near the level of the water surface of the lake and are interrupted by bare expanses covered with a crust of salts (chiefly sodium chloride).

The suitability for crop production of the different types of land in this valley can be predicted with much confidence from the character of the native growth.

Mr. Harry B. Shaw: *The control of seed production in beets.* Practically all sugar-beets seed used in the United States is imported. Successful attempts have been made in Utah, Idaho and Washington States to produce sugar beet seed, but in other regions such attempts have not been very successful, inasmuch as many of the plants have failed to mature seed. Observations were made to ascertain the cause of this. In order to make the subject readily comprehensible attention was invited to the surprising responsiveness of the beet to environment

In these varied manifestations was sought a common factor, or group of factors, which acting at a critical period in the life of the plant, might be found to control the manner of its development. Experiments were carried on in Utah during 1912 to determine, if possible, the nature of the conditions responsible for the variations mentioned.

It was discovered that the condition absolutely necessary for the perfect development of the reproductive parts is a period of restrained growth in the bud rediments of seedlings, or the buds in the crown of so-called mother beets. While in general this condition is brought about by low temperatures (a mean temperature of 38 to 45°F. apparently being required for the sugar beet) when prevailing for several weeks, the necessary degree of growth inhibition may be brought about by other factors, such as pathological conditions, drouth, starvation. The withdrawal of such a period of inhibited metabolism, according to degree, will result in the greater or less degree of approach to foliage conditions, as opposed to the development of reproductive parts.

Thus, by a study of climatic conditions, suitable locations where the production of seed may be assured, can be selected with a considerable degree of certainty. The proper time to plant the mother-beets can also be indicated, so that we may be reasonably certain that the beets will produce seed.

This necessity for a period of inhibited metabolism, and the fact that it may be brought about by the conditions mentioned, may explain the remarkable inflorescence of moribund fruit trees, or of trees that have been girdled, also the abnormal behavior of plants carried from a cool to a warm climate.

The 87th regular meeting was held on February 25, 1913, at the Hotel Cochran. This was the regular annual opening meeting of the Society. Fifty members and forty-two guests were present.

The retiring president, Mr. W. A. Orton, delivered an address entitled *Environmental influences in the pathology of Solanum tuberosum*. This paper was published in this journal **3**: 180. 1913.

The 88th regular meeting was held on April 1, 1913, at the Cosmos Club.

Mr. James T. Jardine was elected to membership.

The following papers were presented.

Dr. G. G. Hedgcock: *Notes on Diseases of Trees Caused by Mistletoes.* Mistletoes are found only on conifers in northern and northeastern United States; only on angiosperms in southeastern and southern portions; and on both in western and southwestern regions, where they are the most widely disseminated. The rate of spread of mistletoes is without doubt very slow. Near Frazer, Colorado, on an old burn in the forest, the rate of spread of *Razoumofskya americana* (Nutt.) Kuntze on the lodge pole pines (*Pinus contorta* Loud.), is estimated to be from 6 to 12 feet per annum, where mechanical expulsion of the seeds aided by winds are the controlling factors. Sporadic infections at much greater distances are caused possibly by birds or animals.

Light is the most important factor in determining the spread of mistletoes of species of both Razoumofskya and Phoradendron. Trees in the open, and in more exposed conditions, whether on ridges or edges of canyons or on level areas are most subject to attack by mistletoes on account of the abundance of light. Mistletoes are stunted by dense

shade, and bear but few, if any seeds, and can not well maintain themselves under such conditions.

One of the immediate effects of the presence of the sinkers of these parasites in the tissues of trees and shrubs, is a tendency to hypertrophy in the immedate region of penetration. In case of species of Phoradendron, unless the mistletoe plant is broken off there is little or no tendency for its lateral sinkers to spread in the tissues of the host, and when broken off, the rate of spread is slow, and no witches brooms are formed. In case of species of Razoumofskya, witches brooms are commonly produced; the lateral sinkers spread in the soft tissues of the host, keeping pace with each year's growth, and sending forth new aerial shoots. The stimulus of the presence of this ramifying network of sinkers of the parasite causes an increase in the number of buds and twigs produced by the limb of the host attached and results in the formation of a more or less dense witches broom. The ability of the mistletoe to grow out to the extremities of the limbs, enables it to send out shoots in the best illuminated portion of the broom, and to bear seeds under the most favorable conditions of light.

All species of mistletoe are considered injurious in their final effect upon trees and shrubs. The leafy Phorandendrons are no doubt less injurious, because of their increased chlorophyll bearing surface and consequent greater ability to manufacture hydrocarbons. The leafless species of Phoradendron are more injurious than the leafy ones. Species of Razoumofskya are most injurious and stunt the growth of the hosts. In view of the slow spread of species of mistletoe in the forest, it will be possible to lessen, if not entirely to shut out these parasites from our future forests, by cutting down all diseased trees on areas where timber sales are conducted.

Prof. A. S. Hitchcock: *Notes on the botany of Trinidad.* Mr. Hitchcock remained on the island of Trinidad from November 25 until December 31 except a few days spent on Tobago. On Trinidad there were collected 350 numbers of grasses representing about 175 species. Grisebach (Fl. Brit. W. Ind.) describes 87 species from the island and Hart (Herb. List, Bot. Dept. Trinidad) lists 112 species. Several species known to grow in Trinidad were not obtained by Mr. Hitchcock but many species were added to the known flora. Among the more interesting regions of the island were: Pitch Lake, where several unique species of grasses were found including *Panicum chloroticum*, growing only in the water-holding depression of the pitch; Aripo and Piarco savannas, isolated low flat grassy openings in the valley of the Caroni river, where were found a probably new species of *Raddia* and *Paspalum serpentinum* Hochst. not found since the original collection by Keppler in Surinam nearly a century ago, and two new species of Panicum; and St. Joseph savanna on the mountain side near the ancient capital of the island, St. Joseph. This savanna is of especial interest because the mountain sides are generally covered with forest except where cleared for cultivation; it has occupied its present position since an indefinitely early period as shown by the flora. The dominant grass is *Trachypogon*

*plumosus*, a species which has not been reported from Trinidad. This species together with others of the association are the common constituents of the savannas found on the Pacific slope of Panama and Central America. In this savanna was found an undescribed species of Axonopus, a beautiful golden annual, allied to A. aureus. At Tabaquite in the center of the island in the original forest or "High woods" was found another undescribed species of Raddia and the rare *Pharus parvifolius* Nash. Several other apparently undescribed species were found on various parts of the island. Most of the species, whose types were from Trinidad were re-collected at their type localities. The results of the expedition to Trinidad and to Jamaica visited earlier on the same trip, were very satisfactory and will supplement the large West Indian collections previously incorporated in the National Herbarium.

C. L. SHEAR, *Corresponding Secretary.*

## THE BIOLOGICAL SOCIETY OF WASHINGTON

The 508th regular meeting was held in the assembly hall of the Cosmos Club February 22, 1913, with President NELSON in the chair and 76 persons present.

The program consisted of a lecture by EDMUND HELLER on *Hunting with Rainey in Africa.* The communication was chiefly descriptive of the maps and numerous lantern slides exhibited and also of the physical features and vegetation of the country, as well as the animals secured during the expedition.

The 509th meeting was held March 8, 1913, with Vice-President PAUL BARTSCH in the chair and 37 persons present.

Under the head of *Brief notes and exhibition of specimens,* WM. PALMER exhibited the head of the small devil ray, *Mobula olfersi*, and a plaster cast made from the same, and explained the feeding habits of this fish. A. C. WEED gave some further account of its habits, and THEODORE GILL added some historical notes about devil fishes. BARTON W. EVERMANN reported results of the sale of blue fox skins from the Pribilof Islands at Lampson's (London) auction on March 7. The 384 skins offered sold at an average price of $56, the highest price being $85.

The regular program consisted of two communications: J. W. GIDLEY gave an account of a fossil camel recently found in America north of the Arctic circle. The only bone found was a phalanx. The species was an extinct one and its occurrence so far north was regarded as further proof that there once existed land connection between the continents by way of Alaska. The paper was discussed by Messrs. WILCOX, O. P. HAY, WEED, GILL, EVERMANN, LYON and others.

The second communication was by PAUL BARTSCH on some *Remarkable Philippine molluska obtained by the U. S. Bureau of Fisheries expedition.* Specimens of the mollusks described were exhibited by the speaker.

The 510th meeting was held March 22, 1913, with Vice-President BARTSCH in the chair and 52 persons present.

BARTON W. EVERMANN reported the executive order of President TAFT made March 3, 1913, setting aside the entire chain of the Aleutian Islands as a wild mammal and bird reservation. The reservation is to be under joint charge of the Departments of Agriculture and of Commerce. A. D. HOPKINS announced the recent organization of a new scientific society, *The Society for the Advancement of Forest Entomology in America.*

The regular program consisted of two communications:

1. *Recent progress in the study and culture of the common eel:* HUGH M. SMITH. This was a comprehensive outline of the recent discoveries concerning the life history of the common eel. Statistics of the commercial uses of the eel and the methods employed abroad for its propagation and distribution were given. Numerous lantern slides were shown.

2. *Tree-shrews:* MARCUS LYON, JR. This paper was based upon a study of many specimens of these squirrel-like, insect-eating animals. Of less than 800 known specimens in museums, the British Museum possesses 355, the U. S. National Museum 324, and about 100 are in other collections. The paper was illustrated by lantern slides. Messrs. BARTSCH and WM. PALMER took part in the discussion.

The 511th meeting was held April 5, 1913, with President NELSON in the chair and 43 persons present.

Under the heading *Brief notes,* PAUL BARTSCH reported observations on the habits of the two common toads of the District of Columbia, *Bufo americanus* and *Bufo fowleri.* HENRY TALBOTT commented on the possible agency of man in the dispersion of animals during the relatively recent geological ages.

The regular program consisted of two communications:

1. *A commercial aspect of paleontology by a layman:* HENRY TALBOTT.

2. *The zoological results of the Denmark expedition to northeast Greenland:* FRITZ JOHANSEN. The speaker, who accompanied the expedition, gave an account of climatic conditions and the fauna and flora encountered. Mammals and birds received the principal attention. Maps and numerous lantern slides were used.

D. E. LANTZ, *Recording Secretary.*

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OF THE

# WASHINGTON ACADEMY OF SCIENCES



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JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES

Vol. III MAY 19, 1913 No. 10

METEOROLOGY.—*The unusual atmospheric haziness during the latter part of 1912.* H. H. Kimball, Weather Bureau.

In a previous paper[1] it has been shown that when first observed at Mount Weather on June 10, 1912, the haziness did not differ materially from that usually observed on the rear of anti-cyclonic areas, except in its unusual density. Subsequently,[2] after the haze had continued almost uninterruptedly for over two months, it was thought that dust from Katmai Volcano, in Alaska, had added its hazing effect to that of purely meteorological origin. A careful compliation of all available observational data relative to unusual haziness or smokiness or decreased atmospheric transparency, during the latter part of 1912, was at once undertaken. The results, of which the following is a summary, will be found in greater detail elsewhere.[3]

*Observational data.* The observations have been derived from the following sources:

1. Descriptive papers and notes in various scientific journals.
2. Extracts from the meteorological reports for June, 1912, of the coöperative observers of the U. S. Weather Bureau.
3. Replies to a circular letter dated December 7, 1912, addressed to officials in charge of Weather Bureau Stations, and requesting copies of all notes made in the Daily Local Record since June 1, 1912, relative to

[1] This Journal, 2, 402, 1912.

[2] Bull. Mt. Weather Observatory, 5, 161.

[3] The effect upon atmospheric transparency of the eruption of Katmai Volcano. Monthly Weather Review. January, 1913. The effect of the atmospheric turbidity of 1912 upon solar radiation intensities and skylight polarization. Bull. Mt. Weather Observatory 5, pt. 5.

the occurrence of any unusually hazy or smoky conditions of the atmosphere, or of unusually brilliant colors at sunrise or sunset.

4. Extracts from the meteorological reports of observers in British Columbia, which were kindly forwarded to the Chief of the U. S. Weather Bureau by the Director of the Meteorological Service of Canada.

5. Extracts from the logs of ships sailing on the North Pacific Ocean in June, 1912.

6. Replies to a circular letter dated December 28, 1912, addressed to members of the Astronomical and Astrophysical Society of America, and requesting copies of any observational data they might have relative to a possible diminution in atmospheric transparency after June 1, 1912.

7. Observations of skylight polarization made by me at Mount Weather, Virginia, and Santa Fe, New Mexico, and pyrheliometric measurements made under my supervision at Mount Weather, Virginia, Madison, Wisconsin, and Lincoln, Nebraska.

*Fall of volcanic ash.* Katmai Volcano which is in the Aleutian Range, Alaska, latitude 58°N., longitude 155°W., approximately, became violently eruptive on the afternoon of June 6, 1912, and continued in a state of great activity for about three days; it was more or less active until the end of October and perhaps until the end of the year. As a result of these eruptions volcanic ash fell between June 6 and June 10 over an area extending in latitude from Rampart, Alaska, latitude 65½°N to Loring, Alaska, latitude 55½°N and in the state of Washington to latitude 48½°N. In longitude the fall extended from Nushagak, Alaska, longitude 158½°W., to Chicken, Alaska, longitude 142°W., to Loring, Alaska, longitude 131° W., and in the state of Washington to longitude 122⅓° W. There also appears to have been a fall of very fine dust at Mount Wilson, California, on August 3–4, which discolored the silver film on the coelostat mirrors.

*Haze and smoke.* The observations show that a hazy or smoky period set in over British Columbia on June 6–8, and over the northwestern part of the United States on June 8–10. This continued until June 11–12, and in the meantime gradually extended eastward. A second hazy or smoky period set in over British Columbia on June 18–20, and over the northwestern part of the United States at about the same time. It extended gradually eastward and southward, and diminished in intensity before the end of the month, especially in the states west of the Rocky Mountains.

It appears that the haziness of these two periods is to be attributed to three different causes, namely:

1. The meteorological conditions, which are especially favorable for the formation of haze on the rear of anti-cyclonic areas. A well defined anti-cylonic area crossed the region east of the Rocky Mountains between June 6 and June 11. Another was central over the Rocky Mountain region between June 17 and June 21, and had passed eastward to the Atlantic ocean by June 24.

2. Smoke from forest fires. There were extensive forest fires in Yukon Territory, Canada, south of Dawson, during the latter part of May, 1912, and in British Columbia about June 6, and between June 11 and June 26. There were no important forest fires in the United States during the month of June.

3. Smoke or dust from Katmai Volcano.

While it is impossible completely to separate the effects of these three causes, it seems evident that the haze and smoke in British Columbia on June 9–10, which was generally accompanied by sulfur fumes, was at least in part of volcanic origin. The same may also be said of the smoke and haze that was particularly noticeable in the states of Washington, Montana, and Wyoming on the same dates, coming, as it did, at about the time of the fall of volcanic ash in the state of Washington. Several observers state that the haze of the latter part of June, as well as that of June 8–12, was a high haze, having some of the characteristics of cirrus clouds, but lacking their fibrous appearance. At Madison, Wisconsin, these cloud-like forms were first observed at 11 a.m. of June 8. If, as seems probable, they consisted of dust from Katmai Volcano, their rate of transportation had been about 73 miles per hour.

The haze appears to have been first observed in Europe between June 20 and 27, altho there is evidence that it was present previous to June 12. It was first observed in Algeria, Africa, on June 19, altho it is probable that it affected the bolometric determinations of solar radiation intensity as early as June 17. The characteristics of the haze, and its effects, appear to have been practically the same in Europe and in northern Africa as in North America.

*Astronomical observations.* While most of the replies to the circular letter addressed to members of the Astronomical and Astrophysica Society of America were to the effect that no data had been obtained bearing upon the question of a diminution in atmospheric transparency during the latter part of 1912, a considerable number furnished data that were confirmatory of such a diminution. For convenience of discussion these data were divided into four classes, as follows:

*a.* Visual observations of a general whiteness of the sky and a lack of transparency of the atmosphere.

*b.* Instrumental determinations of atmospheric transparency, which generally showed a decrease commencing with June or July.

*c.* Unsatisfactory results in astronomical photography, and a general increase in the exposure time required.

*d.* An observed increase in the brilliancy and duration of twilight colors.

These last were confirmatory of observations made by Weather Bureau observers, which indicated that twilight colors were unusually brilliant in October and November, altho at a few stations the colors were the subject of remark as early as June.

The decrease in atmospheric transparency as determined by observations classified under *b* and *c* was generally estimated at from 10 to 20 per cent.

A few observers detected a change in the color of sunlight as well as in that of sky light, apparently due to the excessive absorption or scattering of the shorter wave lengths.

*Pyrheliometric observations.* At Mount Weather, during the last half of 1912, the solar radiation intensities measured with the sun at zenith distance 60° averaged only 83 per cent of the corresponding intensities measured under normal conditions. At Madison, Wisconsin, they were 86 per cent of the average; while at Lincoln, Nebraska, in November, 1912, they averaged only 82 per cent of the intensities measured in November, 1911.

*Sky light polarization.* At the point of maximum polarization the percentage of polarized light averaged about 20 per cent less during the last half of 1912 than the average under normal conditions. Also, the solar and anti-solar distances of the neutral

points of Babinet and Arago, respectively, were materially increased when the sun was above the horizon. With the sun below the horizon the increase was slight, and in some cases there was even a decrease.

These effects upon sky light polarization are in every way similar to the effects observed in 1903 after the eruption of Mount Pelée in 1902.

*The effect of decreased solar radiation intensities upon air temperatures.* In the Bulletin of the Mount Weather Observatory **3**: 111, a diagram is given which shows that diminished solar radiation intensities comparable with those of 1912 occurred in 1884–86, 1891, and 1903. Each of these periods was accompanied and followed by temperatures below the normal in the United States. While the minus temperature departures were not greater than have occurred in other years, they persisted for a greater length of time.

It will be of interest to observe if the present depression in the solar radiation intensity curve is also followed by a long continued cold period in the United States.

PHYSICS.—*Recent theories of heat and radiation.*[1] W. WIEN, Professor of Physics, University of Würzburg.

In a series of lectures at Columbia University, I am treating several problems which are of peculiar interest to modern physics but which already present grave theoretical difficulties. The hypothesis of elements of energy or quanta, as given by Planck and expressed in the well known formula, is indispensable in the statistical treatment of molecular physics. It contains something, however, which lies beyond the commonly accepted system of physical theory. The difficulty in all these problems lies in the fact that one must constantly make use of relations, which are difficult to determine, between the theory of quanta and the older classical theory.

It is impossible as yet to say to what extent the theory of quanta may be applied. Thus far, its application has been confined to

[1] An address delivered before the Washington Academy of Sciences on April 23, 1913.

statistical considerations, and has been successful, but the assumption that the emission of radiation can only take place by quanta has not yet been necessary in any direct physical experiment. The success of the statistical treatment of the phenomena of heat, which has led to the theory of quanta, must be due to some peculiarity of the atom which has found its simplest expression in Planck's hypothesis of quanta, but it remains to be proved whether this assumption represents the true theory of the actual phenomena.

We can not say that the atom radiates energy only thru quanta, for if we accelerate an atom of canal radiation, it must send out energy according to the laws of the electromagnetic field. This energy can be calculated and may reach any arbitrary value. Nor is it possible to overcome this difficulty by assuming that the theory of quanta holds only for periodic variations, and an acceleration is not periodic—for in an alternating field we can impress such vibrations upon a charged atom that it will emit a radiation which is periodic but has nothing to do with the quantum. Again, if we regard heat as the elastic vibration of the atoms, it leads to the conclusion that the theory of quanta must apply there. On the other hand, acoustical vibrations of the same character have nothing to do with the quantum. To apply the theory of quanta to every possible kind of vibration seems, therefore, to lead to impossible consequences.

Once it seemed necessary to limit the application of the theory to the phenomena of irregular molecular motion, and, indeed, we may call Planck's formula the general expression of this irregular motion. From this point of view the theory of quanta tells us that such irregular molecular motion diminishes with temperature and disappears at absolute zero—which is synonymous with the assertion that entropy vanishes at zero as required by the Nernst theorem.

Since the theory of quanta gives us only a formula for the statistical treatment of the partition of energy, it is extremely difficult to find its true physical meaning. We might, of course, content ourselves with applying this statistical treatment to observed phenomena only, merely exchanging the theorem of equipartition

of energy for the general formula of the theory of quanta, but then our need for adequate causes remains unsatisfied, and, besides, we can not in this way avoid being forced to use the theory of quanta in connection with the classical theory of mechanics and electrodynamics. So long as these relations remain unknown, the theory will stand on uncertain ground. At the moment, the best way appears to be to apply the theory of quanta to as large a number as possible of the problems related to the theory of heat.

We may begin with the theory of radiation in the form given by Debye in connection with the theory of Rayleigh and Jeans. And this has the additional advantage of bringing out more clearly the true meaning of the theory of quanta, namely, that another partition of energy takes place, for the energy can only be divided in parts of magnitude $h\nu$.[1] This theory of quanta also lies at the foundation of the theory of specific heat, for the heat of solids is identified with the vibrations of the atom.

The assumption that energy can only be distributed in multiples of $h\nu$ corresponds with the first hypothesis of Planck, that emission and absorption can only take place in aliquot parts of magnitude $h\nu$. But it is well known that this theory is open to serious objections, for a discontinuous absorption of continuous radiation is hardly imaginable. Therefore Planck has now given up the assumption of quanta for the absorption and applies the hypothesis only to the phenomenon of emission, leaving the absorbed energy to reach any arbitrary value. The question then arises, How is it possible to bring this into harmony with the theory of specific heat?

According to Planck's new theory, each atom conceals a quantity of energy the mean value of which is $\frac{h\nu}{2}$ for each free vibration. This energy exceeds the heat energy, even at temperatures which are not very low. Is it therefore possible to assume two kinds of energy of vibrations, one that can not be transferred and another that we call the energy of heat? If elastic vibrations remain in the solid in such an amount that the heat energy is only a small

[1] Where $\nu$ is the number of vibrations and $h$ a universal constant.

fraction of the total energy, how is it possible for the electric conductivity to depend in any considerable degree upon temperature?

The assumption that the energy can be distributed only in multiples of $h\nu$ can, it seems to me, be combined with Planck's new theory only on the hypothesis that the absorption of energy is continuous, but that the absorbed energy exists at first only in the form of energy of electrons. The vibrations of the atoms are identical with the heat energy, and disappear completely at absolute zero, but the energy of the electrons remains and amounts in the mean to $\frac{h\nu}{2}$. On this assumption, the theory of specific heat remains unchanged.

There is one further difficulty with vibrations of the infra-red rays which are assumed in the theory of dispersion to excite elastic vibrations of the molecules. These vibrations would also be heat vibrations, but there would remain an amount $\frac{h\nu}{2}$ not depending on temperature. Perhaps in this case also the motion of the electrons is primary. Then $\frac{h\nu}{2}$ would again represent the energy of the electrons.

The assumption that the electrons have a motion independent of temperature seems *not* to be a new hypothesis. It is founded on the theory of quanta, because the emission can only take place if the energy reaches $h\nu$. Now we know from Zeemann's phenomenon that the radiating particles are moving electrons, and therefore that the electrons must move before the radiation can begin. The theory of diamagnetism also requires the hypothesis of moving electrons independent of temperature. Debye's theory of specific heat is founded directly on the formula of partition of energy. It requires only the assumption that the heat energy is identical with the vibrations of the atoms, and that the forces are those which are assumed in the common theory of elasticity.

A serious difficulty arises in connection with the heat conductivity which should be determined by the elastic waves in the solid. The theory of elasticity is used for the determination of the number of free vibrations, and is thus connected with the

theory of quanta, but we do not yet know how to use this theory to calculate the velocity of molecular vibrations thru the solid.

In considering Planck's new theory, we assume an amount of energy $\frac{h\nu}{2}$ independent of temperature. To find the true law of radiation, one must adopt a definite law of emission, and so obtain a relation between the probability of emission and the rate of increase of energy to the critical value $h\nu$. It would be freer from objection to consider the law of radiation as determined by the considerations offered by Debye, and then to derive inversely the law of emission.

The now well-known theory of electrons was founded on the hypothesis that electric conductivity in metals is determined by free electrons moving in the metal with complete irregularity. In this form the theory can not hold, for H. A. Lorentz has shown that such free electrons must yield a radiation following the law of Rayleigh and Jeans. This radiation, especially for short waves, would be many times greater than is found by observation. The theory of specific heat also shows that only the molecules, not the electrons, possess heat energy.

One might perhaps hope to find a way out of the difficulty by assuming that the number of electrons is small in comparison with the number of atoms, but for low temperatures one would be forced to apply Planck's formula, not only to the atoms but to the electrons as well, and a new difficulty would at once result, since the free electrons can not have a vibration frequency equal to $\nu$. If it were possible to identify the $\nu$ for an electron with the value for an atom, the electrons could no longer be regarded as free and there would be no difference between the free electrons and the electrons fixed in the atom. All the electrons would take part of the heat energy, and, their number being greater than the number of atoms, the value of the specific heat for high temperatures would be too high. There are many circumstances which make it probable that the energy of the electrons is independent of temperature. All emissions of electrons by radiation are independent of temperature, and the electrons coming from hot bodies can be emitted by radiation.

It is possible to develop a theory of electric conductivity if one considers the motion of electrons in metals to be independent of temperature. In this case the conductivity of metals could change only thru variation of the free path of the electrons. The free path of electrons will depend only upon the vibrati ons of the atoms, and must be inversely proportional to the numberof vibrating atoms. It would be more difficult to find the relation between the free path and the amplitude of the vibrations. A statistical consideration shows that the free path must be independent of the partition of the quanta only in case the free path be inversely proportional to the square of the amplitude. The vibrations are supposed to be identical with the elastic vibrations of the solid. In this way, one arrives at a formula for the conductivity, using the values obtained by the theory of elasticity, which agrees with the observations of Kammerlingh-Onnes except at very low temperatures. It also yields the high value for the temperature coefficient for iron and nickel. The derivation of the formula for electric conductivity suggests that the electrons are in irregular motion but the energy of this motion will not depend, as assumed in Drude's theory, on the temperature, for the motion considered remains unchanged even at the lowest temperatures. It is possible to identify this energy of the electrons with the energy $\frac{h\nu}{2}$ of the theory of radiation.

Some considerations have been offered by Einstein, which have considerable importance for the theory of quanta. They relate to fluctuations in the radiant energy caused by the irregularity of the emission. The theory of the Brownian movements founded on the theory of errors has shown such a surprising agreement with observation that it is necessary to take account of this theory in its application to radiation. Using Boltzmann's theorem of the relation between entropy and probability, this can be calculated from the known formula of the entropy of radiation. Applying the law of errors we can calculate the fluctuations of the radiant energy about its mean value. The calculation gives an expression which cannot be interpreted from the mean values for interfering rays, meeting in a point distant from the radiating

surface. The expression which represents the fluctuations contains two terms, one having the form which would result if the elements of energy were concentrated in points of space, the other expressing the fluctuations caused by interference alone.[3] But the second term of the formula also contains the constant $h$ and one can combine the two terms into one, in consequence of which it is not quite certain whether the separation into two terms is due to the physical phenomena. Certain it is that at low temperatures the calculated fluctuations are larger than those caused by interference alone. Inasmuch as this case applies only to radiation which exists free in space it has no relation to observation.

Another case, which was also treated by Einstein, is therefore of great interest here. It concerns the irregular motion of a mirror accelerated by pressure of radiation in free space. In the calculation of this pressure the effect of small velocities vanishes because the pressure is the same on the front and on the back of the mirror. It is therefore necessary to calculate the second term which is proportional to the velocity. The expression for the mean energy of the irregular motion of the mirror is also made up of two terms and is quite analogous to the expression for radiant energy.

If the mirror be suspended in a space filled with radiation from a black body an energy equilibrium is established and it may be expected that the irregularities in the pressure of radiation will reach the magnitude given by the law of equipartition of energy. Therefore the mean energy of the mirror moving in one direction would be $\frac{1}{2}\,kT$.[4] But if we calculate the irregular motions caused by interference alone we shall find them smaller, the mean energy being proportional to $kT$ and independent of $h$. It is unlikely that the mean energy of the real motions would be different from the value $\frac{kT}{2}$, for the irregularities caused by the pressure of radiation must be in equilibrium with the irregularities caused by other thermal phenomena. It seems therefore neces-

[3] From this expression Einstein was led to suggest the assumption that quanta also exist in space.

[4] Where $k$ is the constant of the theory of gases and $T$ the absolute temperature. This quantity of energy is equal to the mean energy of a gas-molecule.

sary to suggest a proper cause for increasing the irregular motions by the amount of the pressure. For the calculation of these irregularities it is altogether probable that the mirror cannot be considered to be a continuous body and the molecular structure of the mirror must be taken into consideration.

The theory of the Röntgen rays, is also connected in some way with the theory of quanta but is founded on purely electromagnetic considerations. Sometime ago I tried to calculate the wave length of the Röntgen rays from the theory of Stokes and Wiechert using only the measurements of energy. The electromagnetic theory gives the energy radiated by the retardation of an electron in a path of definite length. The radiated energy increases with the velocity of the electron and diminishes with the length of the path of retardation. The electron on the other hand radiates only in this path and the wave of electromagnetic disturbance is therefore enclosed between two spheres the centers of which lie at the extremities of the path. Hence the wave length can be calculated from the length of the path, that is, from the velocity and the radiated energy. The energy of the electrons can be calculated from the energy of the excited Röntgenrays. One can therefore calculate the wave length of Röntgen rays from the ratio of the energies of electrons and Röntgen rays. The value found in this way isconsiderably smaller than that found by observations of diffraction. Another way of calculating the wave length of Röntgen rays is given by the theory of quanta. If secondary electrons are excited by Röntgen rays the velocity acquired is much greater than can be explained by the electromagnetic theory. Only a few atoms, however, radiate secondary electrons.

For the simplest explanation of this observation the hypothesis is made that the energy of secondary electrons is derived from the energy accumulated in the atom and having the mean value $\frac{h\nu}{2}$. At first those atoms will radiate which possess a quantity of energy not very different from $h\nu$, and which need only to absorb a small amount of the incident radiation to reach the critical value $h\nu$. These atoms will then radiate and the energy of the emerging

electron is $\frac{m}{2} v^2 = h\nu$. The energy of the secondary electrons being known one can calculate the value of $v$ and obtain a wave length for the Röntgen rays of the same order of magnitude as that which results from experiments in diffraction. It also seems probable that the Röntgen rays affect only the electrons and that the whole absorption is therefore caused by collisions of the secondary electrons with the atoms. In the production of Röntgen rays almost the whole energy of the cathode rays is transformed into heat. Sommerfeld has given a formula uniting the theory of Röntgen rays with the theory of quanta. He puts the action integral (principle of least action) equal to the constant $\frac{h}{2\pi}$, the integration being taken over the time of the molecular action. It is then possible to calculate from the values of the kinetic and potential energies and the constant $h$, the time of molecular action which corresponds to the time of radiation. According to this reasoning the value of the wave lengths resulting from the electromagnetic theory should agree with the value derived from the theory of quanta. In fact much smaller values for the wave lengths result from the electromagnetic theory. Sommerfeld explains this by assuming that the Röntgen rays are not monochromatic but consist of two kinds of radiation, one depending on the nature of the anticathode while the other is the radiation of the retarded electrons. The latter must be polarized in a plane such that the electric vibrations are parallel to the direction of retardation. One can then calculate the radiation of the retarded electrons from the polarized portion of the Röntgen rays. Using the observations upon the polarization of Röntgen rays one now finds an agreement.

Sommerfeld applies his theorem also to the electrons expelled by ultraviolet light by supposing that the energy acquired by the electrons is accumulated by resonance, but with this supposition I cannot agree. In this case a very long time must elapse before emission begins. For the explanation of the emission of electrons by light it seems to me rather that we must take account of the energy concealed in the atom.

One of the phenomena, in which the emission of light undoubtedly takes place thru the collision of molecules and atoms, is the positive rays. There we have atoms and molecules moving with high velocities which can be measured by means of magnetic and electric deflection or by direct methods. One can calculate the mean energy emitted by one atom in one spectral line from the ratio of the emitted intensity in the Doppler line to the number of atoms, which number can be found by observation of the current of positive electricity. On the other hand we find that the particles which are active in the positive rays do not retain their charge but lose it thru collisions with atoms at rest, and after being without charge for a time, they get a new one thru a second collision with a particle at rest. We have therefore always two kinds of particles, one charged and the other uncharged,—neglecting the negatively charged particles, whose number is comparatively small. In the state of equilibrium the number of particles in unit volume losing their charge, is equal to the number receiving a new charge, so that the number of charged as well as of uncharged particles remains constant. But the ratio of the number of charged particles to the number of those uncharged depends upon the number of collisions of both kinds of particles, and is equal to the ratio of the free path of charged particles to the free path of those uncharged. This ratio may be determined by taking away the charged particles in an electric field.

The free path itself can be found if the charged particles are deflected and the distance measured, thru which the uncharged particles must pass before a definite number receive their positive charges. It is found that the free path of the uncharged particles is greater than that of the charged particles but that the ratio of the one to the other depends on the pressure of the gas at rest. This is not in accord with the fundamental concept of the kinetic theory of gases, which demands that the free path be inversely proportional to the pressure. Also the absolute value of the free paths is not inversely proportional to the pressure but at low pressures diminishes more slowly than the pressure increases. These results show that the atoms cannot be regarded as entirely independent of each other. One may also observe that the absorption

of positive rays is not proportional to the pressure but is very much slower. Thus we see that even under these simple conditions the behavior of the atoms is very complicated.

Now it is certain that the emission of light takes place thru collisions of the moving atoms with atoms or molecules at rest and the question is whether or not the collisions effecting the emission of light are the same as the collisions which cause the atoms to lose or receive their charges. If we assume that the two kinds of collisions are the same, we must perforce apply the theory of quanta, because one atom cannot send out less radiation than one quantum. From the free path we know the number of collisions per *cm* of path, and, having found the mean energy emitted by one atom, we may calculate how many collisions are necessary to effect the emission of one quantum of a spectral line, that is, how many collisions must occur for each one which excites one quantum emission. But the emission of light by the positive rays depends very greatly on the velocity of the particles. If the velocity is very small no emission at all can come from the particles. The emission increases rapidly with the velocity but after reaching a maximum value it decreases so that for great velocities it again disappears. The emission of light is therefore associated with a small range of velocities.

In the light emitted by the positive rays we always have two spectral lines, one coming from the molecules at rest and the other from the moving molecules. One might think it possible to find a relation between those two by applying the principle of relativity. If we make the whole system move with the velocity of the moving atoms and in the opposite direction, then the atoms at rest become moving atoms, the moving atoms are now at rest and nothing is changed. One might therefore conclude that the light emitted by the moving atoms differs from the light coming from the atoms at rest only by the amount of the change demanded by Doppler's principle. But we have here a complication in that not only atoms or molecules but also electrons are emitted by atoms in collision and these secondary electrons likewise cause an emission of light if they are absorbed.

All these considerations show that the emission of light by the

positive rays is also a complex phenomenon, in which the emission of a spectral line depends not only on the radiating atom but also on the velocity of the atom or electron which excites the radiation. One must therefore try to make the conditions of experiment still simpler.

Another phenomenon to which it may be possible to apply the theory of quanta is the scintillation caused by the impact of $\alpha$-rays against a phosphorescent body. In a sense we have here an elementary operation because the light, which is emitted in one scintillation is caused by a single $\alpha$-particle. But the amount of energy radiated in the scintillation is much larger than one quantum and it seems that this energy does not come from a single atom of the phosphorescent substance but from a great number of atoms, all excited by the same $\alpha$-particle.

After this survey of the field we are thus compelled to admit that for the moment we have no experiment which permits the observation of a single quantum of energy. With light we cannot hope to make such observations directly because more than thirty quanta are necessary to be perceptible to the eye. In Röntgen rays the element of energy is more than 1000 times larger but here we have no instrument of observation as sensitive as the human eye.

It is therefore unavoidable that in the study of the quanta theory we are confined to statistical methods, and these do not give us a convincing interpretation in terms of physical fact. It is only by applying the theory of quanta to many and widely different phenomena that we can hope to find out the true physical explanation of this novel theory. On the other hand it is evident that hardly more than the first steps have yet been taken and that by far the greater part of the work still remains to be done.

RADIOTELEGRAPHY.—*A Comparison of arc and spark sending apparatus for radiotelegraphy.* L. W. AUSTIN, U. S. Naval Radiotelegraphic Laboratory.

It has been claimed by the users of continuous oscillations in radiotelegraphy that these waves are less absorbed in passing

over the surface of the earth than the damped wave trains produced by spark sending. Several attempts have been made to settle this question by experiment, but over the moderate distances employed no difference in absorption has been observed. In order to extend these experiments to greater distances, a 30-kw. arc operated with 500-volt direct current was installed at the high power station at Arlington, Virginia. At a wave length of 4100 meters, the arc gave an antenna current of from 47 to 53 amperes. Comparisons were made of the received current from this arc and from the 500 cycle spark set giving from 100 to 120 amperes in the antenna. A very careful set of observations of the received currents from the two types of apparatus was made at St. Augustine, Florida, the measurements being taken by the calibrated detector and galvanometer method. The distance between the two stations was 530 nautical miles. The received currents were found to be simply proportional to the radiation currents at Arlington with an error not greater than 10 per cent; that is, at this distance there was no evidence of a difference in the absorption. These results were verified by the shunted telephone method using the slipping contact detector,[1] at New Orleans and also at Key West, both places being approximately 900 miles from Washington.

The receiving apparatus was then placed on the *U.S.S. Arkansas* and taken to Colon, 1800 nautical miles from Arlington. During the two days available for observation at Colon the receiving apparatus was taken to the Naval Radiotelegraphic Station. During these two days, the arc signals were heard at each schedule both day and night, while the spark signals were heard only at night. These observations indicated that at 1800 miles the continuous waves show a smaller degree of absorption than the damped waves. It was not possible, however, to draw this conclusion with certainty, since at the season of the year in which the observations were taken, late December, exceptional days occur which might perhaps affect the continuous oscillations in a different manner from those of the spark.

[1] Journ. Wash. Acad. 1: 8. 1911.

An additional series of observations has been made during the recent voyage of the *Salem* to Gibraltar and return. Here it was found, in verification of the Colon experiments, that for distances over 1400 miles the arc as received in the day time was equal to or somewhat better than the spark, notwithstanding the fact that the spark radiation current at Arlington was considerably more than twice as great as the corresponding arc current. Messages were continuously received with both arc and spark in the day time up to 2100 miles. Several times day signals were heard at greater distances, the arc being uniformly louder. The night signals were heard all the way to Gibraltar.

MINERALOGY.—*Triplite from eastern Nevada.* FRANK L. HESS and W. F. HUNT.[1] Communicated by F. L. Ransome.

Triplite, a manganese fluophosphate of pale salmon color, was found in specimens of tungsten ore sent by G. G. Sims from the Reagan district in the Kern Range, White Pine County, Nevada, to the United States Geological Survey. It occurs with wolframite (hübnerite?), scheelite, pyrite, chalcopyrite, an argentiferous sulfide of bismuth and lead, which is possibly cosalite, native bismuth, and a little sericite. The triplite is in irregular masses, the largest of which is less than an inch in diameter.

The mineral association strongly suggests pegmatitic origin and from its occurrence in other places the presence of triplite in a vein would appear to indicate that the vein is either an end product of differentiation in a pegmatite magma or was deposited by magmatic waters.

An analysis (by W. F. H.) gave only 1.68 per cent of FeO. Previously published analyses of triplite from other localities have shown from 7.69 to 41.42 per cent FeO, and the minerals have been of much darker color. The formula for the Reagan mineral approximates $MnO.P_2O_5.MnF_2$.

A more extended description will be later submitted for publication in the *American Journal of Science*.

[1] Published by permission of the Director of the United States Geological Survey.

HELMINTHOLOGY.—*Notes on Mononchus and Tylenchulus.*
N. A. Cobb. Bureau of Plant Industry.

*Mononchus.* Various observers have suggested that species of the genus *Mononchus* may be injurious to vegetation. For some years the writer has accumulated observations showing the species of this genus to be carnivorous. On various occasions the intestine has been seen to contain other nematodes that have been swallowed whole. On one occasion a *Mononchus* was captured in the act of swallowing another nematode. When *Mononchi* are placed in water with other species of nematodes the latter are sometimes seen suddenly to exhibit active motion, apparently

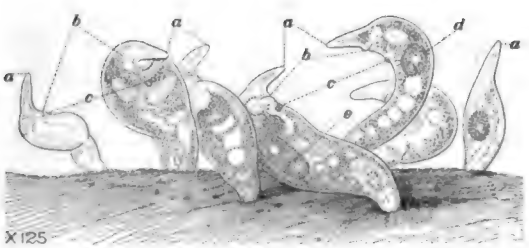


Fig. 1. Seven females of *Tylenchulus semi-penetrans* in various stages, as found on a feeding root of orange tree. The two outside specimens are younger than the others, which are adult or nearly so. A considerable portion of the head end of the worm is inside the root. The roots are injured. *a*, tail end; *b*, vulva; *c*, excretory pore; *d*, immature egg; *e*, ripe egg.

expressive of fear, when touched by the head of one of the *Mononchi*—acting, in fact, as if suddenly nipped or bitten. It would appear that *Mononchi* are beneficial to vegetation, rather than injurious, as the nematodes they feed upon are often injurious species.

*Tylenchulus* (New genus). Mr. E. E. Thomas has recently announced in Circular No. 85 of the California College of Agriculture a very interesting discovery in connection with the roots of citrus trees. Mr. J. R. Hodges, California State Horticultural Inspector, observed nematodes from the roots of orange trees, and concluded they were injurious. Thomas' investigations showed the nematodes to be of common occurrence, but he nevertheless concluded that the species was one not hitherto found on citrus

roots, and Circular No. 85 was issued to call the attention of other investigators to the subject.

The writer has recently examined the nematode mentioned, and finds it a new generic form, for which the name **Tylenchulus** is most appropriate.

**Tylenchulus** has the characters of **Tylenchus**, except that, (1) there is no functional anus; (2) the excretory pore is near the middle of the body, or even farther back in the adult female; (3) there is no male bursa; (4) the male practically loses the spear at the final moult; (5) the cuticle of the female is much thickened when the posterior portion of the body becomes saccate at maturity; (6) the vulva is located in a deep suture.

The type species is:

**Tylenchulus semi-penetrans,** nov. gen., n. sp.

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. | 16. | 21. | 67.[1] | '90. | 94.[2] | |
| 2.2 | 7.1 | 8.7 | 20. | 7.1 | 2.7 | .5 mm. |
| 3.3 | 16. | 29. | | —M | 88. | |
| 2.2 | 2.7 | 2.7 | | 3. | 2.7 | .4 mm. |

Cuticle naked, traversed by 400–500 plain transverse striae. Neck cylindroid, becoming convex-conoid near the continuous head, which is rounded in front. No lips, amphids or eye-spots. Spear and oesophagus typically tylenchoid. Median bulb ellipsoidal, with valve; posterior swelling pyriform to elongated, without valve. Male tail conoid to the somewhat blunt terminus. Posterior part of the adult female saccate, with wide blunt tail bent toward the ventral side. Vulva in the midst of a prominent ventral suture.

Habitat: Parasitic on citrus roots in California and Florida.

Fuller publication with illustrations will follow.

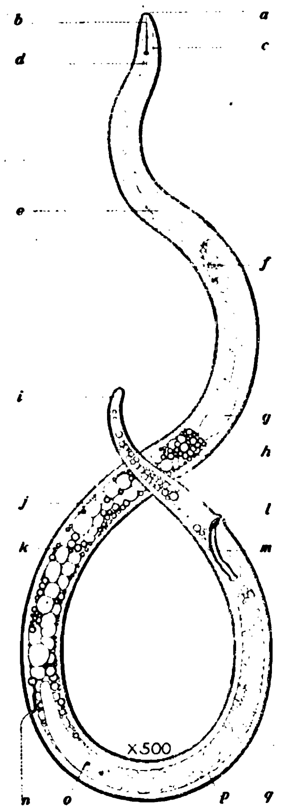


Fig. 2. Nearly adult male of *Tylenchulus semi-penetrans*. *a*, mouth pore; *b*, anterior part of spear; *c*, protruding-muscle of spear; *d*, beginning of oesophagus; *e*, deteriorated median bulb; *f*, nerve-ring; *g*, deteriorated posterior bulb; *h*, beginning of intestine; *i*, terminus; *j*, larger intestinal granule; *k*, smaller intestinal granule; *l*, anus; *m*, left spiculum; *n*, excretory pore; *o*, spermatocyte; *p*, vas deferens; *q*, spermatozoon.

[1] Measurement near the middle of the saccate part.

[2] Arbitrary, as there is no anus.

VITAL STATISTICS.—*A natural population norm.*[1] II. ALFRED J. LOTKA. Communicated by G. K. Burgess.

II. *Proportion of sexes.* In addition to the features discussed in part I of this paper, Table III also shows the calculated and observed ratio of the total number of females to that of males in the population. The calculated figure is obtained as follows:

Let $B_m$ be the total number of male birth per annum. and $N_m$ the total number of males in the population. Let $B_f$, $N_f$ similarly refer to females. Then $b_m$, $b_f$, the male and female birthrates per head per annum, are defined respectively by

$$b_m = \frac{B_m}{N_m}, \quad b_f = \frac{B_f}{N_f} \tag{8}$$

Hence

$$\frac{N_f}{N_m} = \frac{B_f}{B_m} \cdot \frac{b_m}{b_f} \tag{9}$$

Now $\frac{B_f}{B_m}$, the proportion of female births to male births, is a characteristic constant of the population, and in the case under consideration its value was $\frac{1}{1.0382} = 0.9632$. For the values of $b_m$, $b_f$ we have by (4) and Table I

$$\left.\begin{aligned} \frac{1}{b_m} &= 41.35 - 1312 r_m + \cdots \\ \frac{1}{b_f} &= 44.62 - 1467 r_f + \cdots \end{aligned}\right\} \qquad (10)^{2}$$

Hence (9) becomes

$$\frac{N_f}{N_m} = 0.9632 \left\{\frac{44.62 - 1467 r_f}{41.35 - 1312 r_m}\right\} \tag{11}$$

$$= 1.0395 \left\{\frac{1 - 32.878 r_f}{1 - 31.729 r_m}\right\} \tag{12}$$

[1] See this Journal 3: 241–248. 1913.

[2] The convergence of the series (10) is such that in the computation of $b$ and of $c$ ($a$) seven terms had to be retained; but the quotient (12) is much more rapidly convergent, so that only two terms are here required.

In the numerical case here considered $r_m = 0.01431$,
$r_t = 0.01373$.

This gives, for the ratio $\frac{N_t}{N_m}$ the computed value 1.045, as against the observed value 1.054.

III. *Age-distribution at death.* (3) we have for the total number of deaths between the age-limits 0 and $\infty$

$$D = -Nb\int_0^\infty e^{-ra}\dot{p}(a)\,da \tag{13}$$

Similarly, between the age-limits $a$ and $(a + da)$

$$\frac{dD}{da}\,da = -\frac{b}{d}e^{-ra}\dot{p}(a)\,da \tag{14}$$

Introducing a coefficient of age-distribution at death, defined in a manner analogous to that applied to the living population, but denoted by $c'(a)$, this gives

$$c'(a) = -\frac{b}{d}e^{-ra}\dot{p}(a) \tag{15}$$

To find the proportion of deaths between the ages $a_1$ and $a_2$ we integrate

$$\int_{a_1}^{a_2} c'(a)\,da = -\frac{b}{d}\int_{a_1}^{a_2} e^{-ra}\dot{p}(a)\,da \tag{16}$$

$$= -\frac{b}{d}\Big[e^{-ra}p(a)\Big]_{a_1}^{a_2} + \frac{r}{b}\int_{a_1}^{a_2} c(a)\,da \tag{17}$$

The last integral has already been computed in determining the age-distribution in life, so that we can now readily calculate the age-distribution at death. As a matter of fact, in the process of computing the age-distribution in life many of the data required for computing $\Big[e^{-ra}p(a)\Big]_{a_1}^{a_2}$ by series are obtained, so that the work is largely disposed of. The computation was carried out for males only. The results obtained are shown in Table V and figure 5. Here again the agreement between the observed and calculated values is very close.

TABLE V

AGE-DISTRIBUTION AT DEATH (MALES)

| | CALCULATED | OBSERVED |
|---|---|---|
| 0–5 | 429 | 419 |
| 5–10 | 37 | 36 |
| 10–15 | 18 | 18 |
| 15–20 | 21 | 23 |
| 20–25 | 28 | 28 |
| 25–35 | 62 | 59 |
| 35–45 | 69 | 68 |
| 45–55 | 79 | 75 |
| 55–65 | 88 | 88 |
| 65–75 | 93 | 97 |
| 75–∞ | 75 | 89 |
| | 999 | 1000 |

IV. *Average age at death.* The average age at death is given by

$$A_D = \int_0^\infty a\, c'(a)\, da \tag{18}$$

In the case of the stable age distribution this becomes (see 15)

$$A_D = -\frac{b}{d}\int_0^\infty a\, e^{-ra}\, \dot{p}(a)\, da \tag{19}$$

$$= -\frac{b}{d}\Big[a e^{-ra}\, p(a)\Big]_0^\infty + \frac{b}{d}\int_0^\infty (1 - ra)\, e^{-ra}\, p(a)\, da \tag{20}$$

$$= 0 + \frac{1}{d}\int_0^\infty c(a)\, da - \frac{r}{d}\int_0^\infty a\, c(a)\, da \tag{21}$$

$$= \frac{1}{d} - rA_L, \tag{22}$$

if we denote by $A_L$ the mean age of the living population.

In a stationary population we have $r = 0$, $d = d_0$ and hence $A_D = \dfrac{1}{d_0} = l$, where $l$ is the mean length of life, viz., $l = \int_0^\infty p(a)\, da$.

V. *Third equation between b, d and r.* We have so far considered $b$, $d$ and $r$ as connected by two relations, namely equation (2) (or

its equivalent 3), and the defining equation $r = (b - d)$. In actual fact of course $b$, $d$ and $r$ are in every instance completely determined. There must therefore be a third relation between

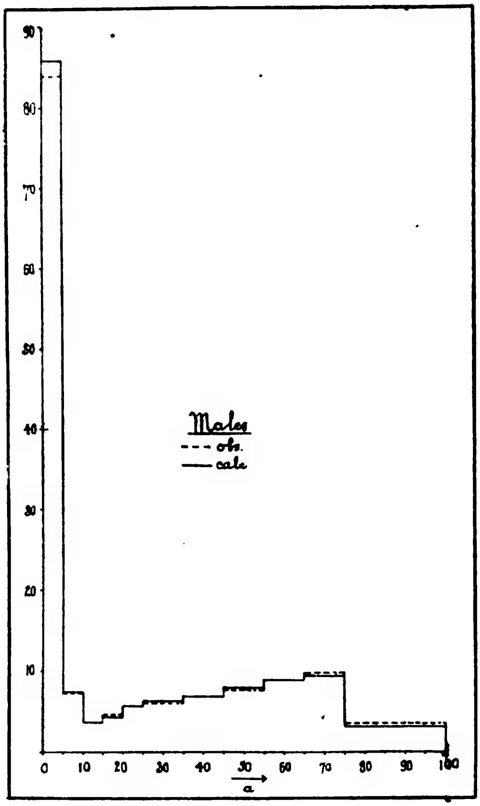


**Fig. 5.** Age-distribution at death, England and Wales 1871–1880.

them. In fact if one male, at age $a$, gives rise, on an average, to $\beta_m(a)$ male births per unit of time, we must have

$$B_m = N_m \int_0^\infty c_m(a)\, \beta_m(a)\, da \tag{25}$$

$$b_m = \int_0^\infty c_m(a)\, \beta_m(a)\, da \tag{26}$$

For the stable age-distribution this becomes by (1)

$$b_m = b_m \int_0^\infty e^{-ra}\, p_m(a)\, \beta_m(a)\, da \tag{27}$$

$$1 = \int_0^\infty e^{-ra}\, p_m(a)\, \beta_m(a)\, da \tag{28}$$

an equation which determines $r$.

Equation (28) gives rise to two reflections.

In the first place it can be seen by inspection, that $r \gtreqless 0$ according as $\int_0^\infty p_m(a)\, \beta_m(a)\, da \gtreqless 1$. This is due to the fact that this last integral represents the ratio of the total male births in two successive generations.

The second conclusion which we may draw from equation (28) is at first sight somewhat surprising. In that equation we may, without altering its meaning in any way, write the limits of the integral $a_1$ and $a_2$, instead of 0 and $\infty$, if we denote by $a_1$ and $a_2$ the lower and upper limits of the reproductive period. For outside these age limits the function $\beta(a)$ has everywhere the value 0, so that the terms of the original integral outside these limits contribute nothing to the numerical value of the integral. This being so, the per cent rate of increase of a population in which the stable age-distribution has become established is quite independent of any factors which may affect the life of individuals outside the reproductive age limits—so long as conditions within these limits remain unchanged. Thus, if we were dealing with a herd of cattle, for instance, it is quite immaterial, so far as the effect upon $r$ is concerned, how we slaughter the cattle of the herd, so long as we spare the individuals of breeding age. This is a somewhat surprising result, especially as it applies not only to the superannuated, but also to the young, immature cattle.

## ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

BOTANY.—*The catalpa septum: a factor in distinguishing hardy catalpa.* WILLIAM H. LAMB, Forest Service. Proceedings of the Society of American Foresters, **7**: No. 1. 1912.

This is a discussion of the distinguishing characteristics of hardy catalpa (*Catalpa speciosa*), and common catalpa (*Catalpa catalpa*), with emphasis upon the septum as a distinguishing feature. The septum is the long wrinkled partition within the pod, along which the seeds are arranged. The septum of hardy catalpa is greatly thickened along the middle, giving it a rounded appearance in general outline. The septum of common catalpa, on the other hand, is only slightly thickened along the middle and appears relatively flat. This variation in shape furnishes us with a valuable means for recognizing hardy catalpa. Diagramatic drawings of enlarged sections of typical septa have been made to illustrate this important distinction. W. H. L.

ZOOLOGY.—*Crinoidea* (supplement). AUSTIN HOBART CLARK. Ergebnisse der Hamburger südwest-australischen Forschungsreise 1905, Bd. **4**: Lief. 6: S. 307–315, Taf. 4. 1913.

Since the publication of the author's memoir on the crinoids of west Australia (this series, **3**, part 13, pp. 435-467) additional specimens collected by the Hamburg Southwest Australian Expedition have come to light. An account of these, including the description of a new genus (*Petasometra*) and species (*P. helianthoides*), is here given. In an appendix is a list of annotations by which the information included in the original memoir, written three years ago, is brought up to date.

A. H. C.

ICHTHYOLOGY.—*The sense of smell in fishes.* G. H. PARKER and R. E. SHELDON. Bulletin of the Bureau of Fisheries, **32**:33–46. 1912. Issued May 3, 1913.

The common belief that fishes have a sense of smell has been hitherto without the support of physiological evidence. In this paper are recorded the results of experiments with three common species of fishes which show reactions undoubtedly dependent upon the olfactory apparatus.

1. A current of water passes thru the nasal chambers of many fishes in a direction from anterior to posterior. It may be produced by ciliary action (*Ameiurus*), by pressure due to the action of the respiratory muscles (*Fundulus*), or it may be a part of the true respiratory current (*Mustelus*).

2. By means of this current dissolved substances in the water are brought into contact with the olfactory surfaces.

3. Fishes distinguish packets containing hidden food from similar packets without food.

4. This power of distinguishing the two classes of packets is lost when the olfactory tracts are cut, when the anterior olfactory apertures are stitched up or when the apertures are plugged with cotton wool. It is revived on reopening the apertures by taking out the stiches or removing the cotton wool.

5. *Mustelus* and *Ameiurus* discover their food chiefly thru the olfactory sense; *Fundulus* uses the eyes in addition to the olfactory organs for this purpose.

6. *Mustelus, Fundulus,* and *Ameiurus* use the olfactory organs to scent food much as land animals do; these organs are true organs of smell, i.e., distance receptors for the chemical sense. G. H. P. and R. E. S.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 718th meeting was held on January 18, 1913, at the Cosmos Club, President ABBOT in the chair; about 35 persons present. The minutes of the 716th meeting were read and approved.

Mr. M. D. HERSEY presented a paper on *A mechanical model of the least square adjustment*. The apparatus exhibited consisted of a sheet of coördinate paper mounted on a board for the plotting of points, a light aluminum rod, and a supply of rubber elastics and push pins. The values under discussion were plotted by the push pins, allowance being made for the unstretched lengths of the elastics by which the bar was suspended. The model was used to show the mechanical adjustment of the tests of a mercury barometer; the results were compared with those by the usual solution of normal equations. The speaker discussed methods for weighting different observations, the determination of the probable error by the model, and the application of the principle for solution of case involving several unknowns. The paper was discussed by Messrs. WHITE, RINES, and ABBOT.

Mr. H. C. DICKINSON presented a paper by himself and Mr. E. F. MUELLER on *New calorimetric resistance thermometers*, describing and exhibiting the improved type of sensitive resistance thermometer developed at the Bureau of Standards. A coil of 0.1 mm. platinum wire is wound on a thin mica strip and enclosed with mica insulation in a platinum (or silver) sheath pressing firmly on the flat coil. The upper end of the sheath is fused or soldered to a glass tube carrying the leads. The instrument may be used from $-180°$ to $500°$. The constancy of this type is shown by the fact that for the best of them the resistance at $0°$ has not changed more than 3 or 4 parts per million in three years, an amount that may be due to impurities in ice used, errors in resistance standards, or changes in the leads. Thermometers of this type are now being manufactured commercially. Mr. MARVIN discussed certain details of their construction.

Mr. H. L. CURTIS spoke on *Some properties of electric condensers*. A perfect condenser should maintain a constant capacity independent of outside conditions, should have an infinite insulation resistance and no absorption. The problems of construction are mechanical and electrical; the first being to keep the plates so they will have the same area and be the same distance apart, and the second being the insulation resistance and the anomalies of the dielectric. The speaker discussed these problems for the air or gas, mica, paper, and glass condensers.

For the gas dielectric the greater problem is the mechanical one, while for the solid dielectric the question of anomalies is the more serious. The paper was discussed by Mr. Gray with reference to values of capacity at different voltages.

The Secretary read communications inviting members of the Society to attend the meeting of the Washington Academy of Sciences on January 30 at the Cosmos Club to hear an illustrated address, *Some observations of the volcano Kilauea in action*, by Dr. A. L. Day; and also to attend a meeting on January 27, at the Bureau of Standards to hear Professor Magie of Princeton on *Our conception of energy*.

The 719th meeting was held on February 1, 1913, at the Cosmos Club, with President Abbot in the chair and 16 persons present. The minutes of the 718th meeting were read and approved.

By invitation Mr. Alfred Lotka presented an illustrated paper on *A natural population norm*. Published in full in this Journal, **3**: 241, 289. 1913. The paper was discussed by Messrs. Burgess, Wolff, Burrows, and Abbot.

Under informal communications Mr. Abbot spoke of the recent work conducted and the results obtained with the pyrheliometer showing that a standard scale of pyrheliometry is now well established. Mr. Humphreys offered an explanation of the present mild winter in the District of Columbia and neighboring region in that the high pressure center usually located in the East Atlantic off Gibraltar has shifted of late to the neighborhood of the Bermudas and in consequence we receive with southerly winds the mild marine climate. No cause for the shift could be assigned. Mr. Kimball spoke of the remarkable diminution since June 10, 1912, of the Solar radiation as measured at the surface of the Earth; during the six months to December the radiation was but 83 per cent of what it had been in previous years at Mt. Weather. There appears to be some relation with the eruption of the Volcano Katmai in Alaska of June 6, 1912. A study of the results promises to give interesting light on the circulation of the atmosphere.

The 720th meeting was held on February 15, 1913, at the Cosmos Club. President Abbot in the chair; 50 persons present.

The evening was devoted to the address of the retiring President, Mr. E. B. Rosa, on *The function of research in the regulation of natural monopolies*. Published in full in this Journal, **3**: 201. 1913.

The 721st meeting was held on March 1, 1913 at the Cosmos Club. This meeting was held conjointly with the Washington Academy of Sciences. President Tittmann, of the Academy, presided. There were about 200 persons present.

The Right Honorable James Bryce, O.M., British Ambassador to the United States, gave an address on *The physical aspects of Australia and New Zealand*. The islands of New Zealand are very mountainous and the scenery of great beauty. The climate is generally moist. A

large part of the country is suitable for cultivation but because of the distance from market the raising of cattle and sheep is the industry most developed. The vegetation is remarkable, particularly the tree ferns, which grow to great size. The native Maori people are much like the Hawaiians in character and language and are of a very high order of intelligence. Australia is quite unlike New Zealand in its physical features. The interior is a great plain and is generally quite arid as the outside fringe of mountains on all sides prevents the rains from reaching it. The presence of copious deep level water makes possible the use of artesian wells and much of the interior may be developed by irrigation. The interesting question as to the source of this deep level water was discussed briefly. The flora and fauna are peculiar. The aborigines are entirely unlike those of New Zealand, being of negroid type and of a very low state of culture. The address was illustrated by wall maps and lantern slides.

To express the appreciation of the meeting for the delightful and instructive address, the President called for a rising vote, which was unanimous.

The 722d meeting was held on March 15, 1913, at the Cosmos Club. Vice-President FISCHER in the chair; 27 persons present. The minutes of the 719, 720, and 721st meetings were read and approved.

Because of illness, Mr. G. W. SPENCER, who was to have presented a paper *Relationship between terrestrial gravity and observed Earth movements of eastern America*, was unable to address the meeting.

Mr. I. G. PRIEST read a paper on *A photometric error sometimes accompanying the use of a pair of nicols, and a proposal for its elimination*, illustrated with lantern slides. In extensive optical trains such as occur in spectrophotometers and colorimeters the use of a pair of nicols following the simple theory may be impaired by oblique reflections of the plane polarized beam whose plane of polarization is rotated with the rotating nicol. An example was cited and illustrated by lantern slides and formula given showing variation of intensity of beam from proportionality to the square of the sine of the angle $\theta$ thru which analyzing nicol is rotated from the position of "crossed nicols." A triplet of nicols in train instead of a pair is proposed with end nicols fixed and middle one rotating, in which case, with principal planes of end nicols parallel, the intensity is proportional to $\sin^4 \theta$, and if perpendicular, to $\sin^2 \theta \cos^2 \theta$. Trouble may be more simply eliminated by using only a pair of nicols but rotating the polarizer instead of the analyzer, provided the beam incident on polarizer is entirely unpolarized. The paper was discussed by Messrs. COBLENTZ and TILLYER.

Under informal communications Mr. W. BOWIE presented a paper on *The precise level net of the United States*, giving the results of the recent adjustment by the Coast and Geodetic Survey of the different circuits of the precise leveling net of the United States. 44,720 kilometers of leveling have been run in two directions and about 10,700 permanent bench marks have been placed in all but seven states. The values

resulting from the adjustment will probably be held as standard elevations for an indefinite time and be of great benefit to surveyors and engineers. New circuits will be fitted to the old levelings as, while they would theoretically give new and better values, the changes would be small as regards practical use. The paper was discussed by Messrs. C. A. Briggs, Rines, Wright, Humphreys, and Sosman.

Mr. W. J. Humphreys presented an illustrated paper on *Factors in climatic changes in the past.* The suggestion that the important factor has been the presence of veils of volcanic dust in the atmosphere was made in a revised form. Considerations of the material, density, and size of particles of volcanic dust show that interference with ingoing radiation would be five or more times that on outgoing radiation, which would mean lower temperature. Calculations show that one-tenth cubic mile of dust would account for a glacial period.

The 723d meeting was held on March 29, 1913, at the Cosmos Club. President Abbot in the chair; about 40 persons present. The minutes of the 722d meeting were read and approved.

Mr. L. W. Austin presented a paper on *Recent experiments in radiotelegraphy.* Owing to non-receipt of data from S.S. *Salem* giving results of tests between the Arlington station and the *Salem* while en route to and from Gibraltar the speaker could not report on this work as he had expected. The results of the United States Navy experiments of 1909–10 were reviewed and formulae discussed. The high power station at Arlington was briefly described. In it are incorporated the suggestions and ideas developed in the 1909–10 work. It differs from most high power stations in that it has a three tower arrangement for antennae instead of the more usual umbrella type; one tower is 600 feet and the other two each 450 feet high. Ground resistance has been practically eliminated by grounding with copper net—this was found to be essential and makes no difference in the radiant energy. The seasonal variation of received signals was discussed—the energy received dropping during the summer. Difference in ease of transmission during day and night was pointed out; day conditions are generally more constant while at night there are great fluctuations. Discussed by Mr. Bauer as to greater ease of transmission along magnetic meridians; by Mr. Abbot as to magnitude of difference between day and night conditions; by Messrs. White, Humphreys, and Wolff as to the calculations at Arlington.

Mr. F. A. Kolster spoke on *National and international regulation of radiocommunication.* The uses and chief purposes of radiocommunication are protection to life at sea, aid to navigation, communication between ship and ship and shore, and naval and military operations. The first regulation conference held in 1906 in Berlin was due largely to attempts made to monopolize the business and the great amount of interference due to amateurs. At the second conference held in 1912, in London the discussion was practically confined to matters relating to operation of apparatus. Interference can be best avoided by restricting use of waves of definite lengths for definite purposes, e.g., wave lengths between 600 and

1600 meters are used only for naval and military purposes. In most foreign countries amateurs are not allowed to operate; in the United States they may do so but are restricted to the use of wave less than 200 meters in length. The speaker read and discussed at length some of the regulations. The next International Conference will be held in Washington in 1917. Paper was discussed by Mr. Bowie as to importance of radiotelegraphy in the determination of longitude on islands and in unexplored regions; also by Messrs. Bauer, Rines and Abbot. Mr. Bauer told of the receipt at Salah, through the courtesy of a French officer, of time signals by the magnetic party crossing the Sahara, the signals being received directly from Paris, 1600 miles distant.

J. A. Fleming, *Secretary.*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 267th meeting was held on March 12, 1913, at the Cosmos Club.

The following informal communications were presented: *An overthrust fault in miniature from Montana:* G. S. Rogers; *Some new occurrences of alunite:* F. C. Schrader.

### REGULAR PROGRAM

*Geology of a portion of Northwest Alaska* (Illustrated): Philip S. Smith; *A Pleistocene cave in Devonian limestone near Cumberland, Maryland:* J. W. Gidley.

*The work of the Alaska Railroad Commission:* Alfred H. Brooks. In accordance with an act of Congress, approved August 24, 1912, President Taft appointed on August 31 the Alaska Railroad Commission as follows: Major J. J. Morrow, U. S. Army, Chairman; Alfred H. Brooks, U. S. Geological Survey, Vice-Chairman; Lieut.-Commander Leonard M. Cox, U. S. Navy; Collin M. Ingersoll, Consulting railway engineer, New York City.

The Commission sailed from Seattle, September 10, and spent some two and a half months in field investigations. The work included an examination of all the harbors on the Pacific seaboard of Alaska which have been suggested as coastal terminals, also all the existing railways of central Alaska. The journey was extended to the lower Susitna Valley, and later to Fairbanks by the winter trail which follows closely one of the proposed railway routes into the Yukon basin.

The Commission began its office work on December 2. This included a careful analysis of all the engineering data available regarding Alaska railway routes, aggregating some 3000 miles in length. On the basis of this information estimates of construction and operating costs were made for some sixteen different lines. A fairly comprehensive study was also made of the data relating to the resources of central Alaska, including minerals, agriculture, forests, and water power. The work of the Commission included a consideration of the existing transportation conditions in Alaska, together with statistics on commerce. Climate

and distribution of population were also among the subjects investigated. The report was submitted to the President on January 20, 1913, and has since been published under the title, *Railway Routes in Alaska:* Document No. 1346 H. R. 62d Cong., 2d Session, 172 pp., 1913. The maps and profiles were submitted on March 1, 1913. These are now in print as Part II of the report.

RALPH W. RICHARDS, *Secretary.*

The 268th meeting was held on March 26, 1913, at the Cosmos Club. At the session of the council preceding the open meeting the following members were elected delegates to represent the Society at the meeting of the International Geological Congress at Toronto, August 7 to 12, 1913:—F. L. RANSOME, DAVID WHITE, J. S. DILLER, E. O. ULRICH.

The following informal communications were presented: *A discovery of gypsum and anhydrite in a drill hole at Centerville, Iowa:* F. C. GREENE.

*Niter near Melrose, Montana:* RALPH W. RICHARDS. Niter is found as thin crusts on the surface of black limestone presumably of Devonian age on Camp Creek about 3½ miles northeast of Melrose; it is also disseminated in veinlets to a less extent thru the rock. The purest salt occurs as a snowy white to slightly yellow mass of needle-like crystals, in the loose rock talus at the base of ledges. About 86 per cent of the mass is soluble in water; the soluble portion has been analyzed by R. H. Bailey and the following results obtained.

| | |
|---|---|
| Calcium sulfate | 13.94 |
| Sodium sulfate | 3.30 |
| Sodium chloride | 20.42 |
| Sodium nitrate | 21.77 |
| Potassium nitrate | 39.48 |

The nitrates make up about 61.25 per cent of the total water soluble portion. An attempt was also made to determine the niter present in the limestones; the water soluble portion was found to range from 1 to 5 per cent.

REGULAR PROGRAM

*Quaternary problems of central Alaska:* HENRY M. EAKIN. The present drainage of Alaska is evidently superimposed upon an older topography whose drainage had little resemblance in arrangement to that of today. This is shown by the topographic irregularities of the valleys of the present master streams that were developed, in part at least, in Quaternary time; in the irregular distribution of alluvial plains that represent old erosional depressions; and in old valleys that are now traversed by inadequate streams or are entirely abandoned. The assumption of crustal movements to account for these features is precluded by the irregularities of the lowland basins; by the flood plains of tributaries in reaches where the trunk stream has no flood plain, and in the wide accordance in elevation of high terraces and silt deposits.

The hypothesis advanced involves the ponding of water in the old

drainage basins by glacial obstruction: the establishment of drainage lines across the lowest available divides; and the topographic adjustment of the present river systems. The maximum known extent of ice in late geologic time is inadequate to the requirements of this hypothesis, but data bearing on this point are incomplete.

*Igneous rocks of the Raton Mesa Region:* J. B. MERTIE, JR. The mesas near Raton, New Mexico, have resulted from the differential effect of erosion upon a series of lava flows and the surrounding sedimentary rocks. The vulcanism began in post-Eocene time and continued intermittently to recent time. The oldest flows cap the highest mesas, thus preserving the original land surface over which they spread; while the latest flows lie in the present lowlands. Four series of flows have been recognized on the basis of erosional unconformities which separate them. The first or oldest series is composed of numerous fissure flows of great thickness and originally of great extent. They are uniformly olivine basalts. The second series is not materially different from the first. The third series contains a variety of rock types, among which hornblende hyalorhyolite, ægerite trachyte, augite andesite, hauyne basalt, basanite, quartz basalt, and normal olivine basalt have been recognized. Many of these flows came from central vents, and most of the resulting rock types show greater or less amounts of glass. The flows of the fourth series have come in every instance from volcanic cones of the central type and are uniformly glassy in character. They are, so far as observed, normal olivine basalts. The dyke rocks of the area include kersantites, vogesites, camptonites, limburgites, and nephelinites.

The results of the investigation show a gradual change from the fissure to the central type of eruption, an increasing viscosity in the lavas accompanied by explosive volcanic action, and the development of numerous extreme rock types, or magmatic end products. All these phenomena are interpreted as the results of dying volcanic activity.

*Remarks on the geology of the Bahama Islands, and on the formation of the Floridian and Bahaman oolites:* THOMAS WAYLAND VAUGHAN. The author gave a brief résumé of some studies he has conducted during the past seven years under the joint auspices of the United States Geological Survey and the Department of Marine Biology of the Carnegie Institution of Washington. The remarks on the geology of the Bahamas were based on observations made and material collected by him as a member of an expedition conducted by Dr. A. G. Mayer of the latter organization, during last April and May.

The submarine and subaerial topographic features of the Bahamas were described briefly. The general country rock, across the Great Bahama Bank from Gun Cay to Northwest Passage and that of New Province and Andros islands, is oolite similar to the oolite of Florida. Along the windward faces of the islands ridges of wind-blown material rising above the lower platforms are usual.

The studies of Dall, Sanford, and the author, in association with Geo. C. Matson, led to the opinion that the finely divided calcium car-

bonate oozes so abundant in Florida waters are chemical precipitates. Drew showed in 1911 that denitrifying bacteria are an important agent in effecting this precipitation in Florida waters; and in 1912 he extended his researches to the Bahamas, where he found them enormously abundant and active, as many as 160,000,000 being found in .1 cc. of surface mud on the west side of Andros Island. Rainey in 1858, Harting in 1871, and Linck in 1903 (and perhaps others), showed that calcium carbonate precipitated by an alkali forms spherulites; and Drew noted a similar tendency of the calcium carbonate precipitated on his cultures. Murray and Irvine showed that at higher temperature chemically precipitated calcium carbonate is of the aragonite form.

Bahaman shoal water bottom muds were collected at many stations, especially through South Bight and off its west end. The muds when collected were not observed to contain oolite grains, altho these may have been present and may have escaped notice, but all the muds when examined at the end of November did contain such grains, which ranged from spherulites 0.004 or 0.006 mm. in diameter, to grains of ordinary size, 0.10 to 0.80 mm. in diameter. The muds are composed of a mixture of aragonite and calcite. In order to test the growth of the grains, samples of a number of muds were strained through No. 10 bolting cloth, which has a mesh of about 0.13 mm. in size, and the fine material was put into bottles containing sea-water. During the first half of March a portion of each sample was studied. The formation of oolite grains was found to be in progress in every sample, and numerous grains were so large as manifestly to preclude their having passed thru the mesh of the bolting cloth. The experiments demonstrated both the increase in the number of spherulites and the increase in the size of the grains. The precipitated calcium carbonate may segregate around a variety of nuclei, for instance, spherulites formed of precipitated calcium carbonate, small grains of sand, shells of foraminifera, and gas-bubbles.

Altho there is need for additional study of the factors that accelerate, retard, or inhibit the formation of spherulites and the growth of the grains, the empirical facts in the process of the formation of the Floridian and Bahaman oolites are demonstrated. They are as follows: (1) Denitrifying bacteria are very active in the shoal waters of both regions and are precipitating enormous quantities of calcium carbonate which is largely aragonite; (2) this chemically precipitated calcium carbonate may form spherulites which by accretion may become oolite grains of the usual size, or it may accumulate around a variety of nuclei to build such grains.

Two important deductions may be made from the knowledge of this process, viz.: (1) Neither the Bahamas nor the oolitic keys of southern Florida are coral islands, but they have been formed by this other process. Elevated coral rock is exceedingly scarce in the Bahamas and the recent reef of Andros is comparatively insignificant as a constructional geologic agent. The material composing the land masses and much of the submarine platforms of the Bahamas are thus removed

from the category of "coral rock" and the living reef reduced to a subordinate ratio as a builder of limestone. (2) Drew's unfortunately incompleted studies of the distribution of denitrifying bacteria have shown them to be most prevalent in the shoal-waters of the tropics. They therefore conform to the principles enunciated by Murray for the distribution of lime secreting organisms. By combining the results of Drew and Murray, the deduction seems warranted that great limestone formations, whether they be composed of organic or of chemically precipitated calcium carbonate, were laid down in waters of which at least the surface temperatures were warm, if not actually tropical.

FRANK L. HESS, *Secretary.*

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 466th regular meeting of the Anthropological Society of Washington was held in the National Museum February 18, 1913, the President, George R. Stetson in the chair.

Professor W. H. HOLMES read a paper on: *Agricultural implements of the mound-builders.* The rich alluvial prairie of the middle Mississippi valley is especially suited to the practice of agriculture, and here are found large numbers of skillfully made flint blades of large size adapted to hafting as hoes and showing unmistakable evidence of long usage in operations that gave the edge a high degree of polish. They are made of grayish flint or chert, which occurs in the form of flattish nodules especially in southern Illinois. These nodules were readily shaped by fracture with stone hammers, and vast numbers were worked up by the mound-building tribes. The processes of manufacture were demonstrated by the speaker and it was shown with what ease and rapidity the blades could be made.

It was also shown by examples obtained from the Missouri river tribes that hoes made of scapulae of the buffalo were in use in very recent times and that the hoes found by excavation in ancient sites near Omaha correspond to these recent Indian forms in shape, manner of hafting, and surface polish, and that both display, altho in bone, precisely the same kind of polish and markings as the similarly shaped hoes of flint. It was suggested that these flint hoes were modeled after scapular hoes, since these were in general used by the tribes and have doubtless been in use from very early times among all the tribes advanced to the sedentary agricultural stage of culture.

With regard to questions of the antiquity of the stone and bone hoes which have recently been raised, it was suggested that since the buffalo was a comparatively recent arrival in the Mississippi valley, a culture in which the bones of buffalo are represented must be younger, not older, than that of the mound-builders, since no traces or representations of the buffalo are found within the older Indian mounds.

This paper was briefly discussed, Mr. Stetson read some notes concerning stone articles recently found in Britain, and Professor Holmes commented thereon and then read a paper on the *Scope and relationship*

*of history and archaeology,* in abstract as follows: The term history as applied to the human race is a comprehensive designation corresponding to Anthropology which is defined as the science of man. According to Powell's classification Anthropology may be considered under seven heads giving rise to as many branches of research, as follows: Somatology psychology, philology, sociology, sophiology, technology, and esthetology.

The records or sources of information to be drawn upon in these researches are comprised under two principal heads: Intentional or purposeful records, and non-intentional or fortuitous records.

The intentional records are of five forms (1) The pictorial—pictographs; (2) the commemorative—monumental structures; (3) oral—tradition and lore; (4) objective-mnemonic—quipu, wampum; (5) inscribed, written—glyphic, alphabetic. Fortuitous records take numerous forms: (1) The diversified material results of human activities in which the commemorative-mnemonic motives are absent but which comprise the great body of the products of handicraft; (2) the immaterial results of human activity as embodied in language, beliefs, customs, music, philosophy, etc.; (3) the ever existing unpremeditated body of memories which accrue to each generation and are in part transmitted adventitiously; (4) the record embodied in the physical constitution of man which when properly read, tells the story of his development from lower forms; (5) the records of intellectual growth and powers to be sought and studied in the constitution of the mind; (6) the environments which may be made to reveal the story of the nurture and upbuilding of the race throughout the past.

It is from these diversified records that the story of the seven grand divisions of the history of man must be drawn. Archeology stands apart from this classification of the science, traversing in its own way the entire field of research. It claims for its own more especially that which is old or ancient in this vast body of data. It is even called upon to pick up the lost lines of the earlier written records as with the shadowy beginnings of glyphic and phonetic writing and restore them to the historian.

It must follow back the obscure trails of tradition and substantiate or discredit the lore of the fathers. It must interpret the pictorial records inscribed by the ancients on rock faces and cavern walls. Archeology is thus the great retriever of history.

The services of archeologic science are equally potent in the field of the fortuitous records for it reads that which was never intended to be read. The products of human handicraft, present and past, which have automatically recorded the doings of the ages are made to tell the story of the struggles, the defeats, and the triumph of humanity. The fortuitous records embodied in the non-material products of man's activities of today, are made to cast a strong light on the history and significance of the material things of the past. Even the body of knowledge gathered from many sources, stored in the memory of the living, may be made to illumine the past; and the physical and psychical man are in themselves records and may be made to tell the story of their own becoming and to

explain the activities and the products of activity thruout the ages. All that archeology gathers from this wide field of research is contributed to the volume of written history. It is thus not only the retriever of that which was treasured and lost, but also the savior and conservator of vast resources of history of which no man had previously taken heed.

In the great work of assembling the scattered pages and completing the volume of the history of man, archeology may well claim first place among the contributing sciences.

This paper was discussed by Messrs Casonowicz, Carroll, Swanton, Stetson, Hewitt, and others.

The 467th regular meeting was held on March 18, 1913, at the National Museum, the President, Mr. Stetson, in the chair.

Dr. John R. Swanton read a paper on *The Creek confederacy*. After explaining the geographical and linguistic positions of the tribes of the Creek confederacy with the assistance of a map, Dr. Swanton traced the evolution of the confederation from a small nucleus of tribes speaking the Muskogee language to a large association, comprising a number of Hitchiti speaking people, the Alabama, Koasati, some of the Apalachee and Yamasi part of the Natchez, the Yuchi, and, for a time, some of the Shawnee. He showed that this association was facilitated thru the institution of a dual division of towns into white or peace towns and red or war towns, the towns of each division, or "fire," considering each other friends or allies and having opposing but not warlike relations with the towns of the other "fire." It thus happened that when an outside town or tribe came to be accepted as a "friend" of one of the white or red towns in the confederacy its position with reference to all of the other white and red towns was thus established and it entered into the confederate scheme. The communication of other common features to the new towns also took place, altho more slowly. Such features were the "green corn dance" or busk, or perhaps rather the Muskogee form of it, participation in common altho irregular councils, and the adoption of Muskogee as the standard language of intercommunication. The actual discontinuance of the proper languages of the various members of the confederacy was, fortunately for the ethnologist, much slower, several of them having persisted down to the present day. Thru the progressive adoption of smaller tribes and the practical destruction of some in warfare, a process accelerated by white contact, the Creek confederacy came to be almost the sole representative of eastern Muskhogean culture, and even influenced the culture of the Chickasaw to a marked degree. The great Choctaw body, on the other hand, maintained its cultural independence and was never dominated by the Creeks. In sharp contrast to the Creeks, whose national structure was built up by fitting numerous distantly related tribes into an artificial fraternal scheme, the Choctaw seem to have owed their sense of unity to an actual homogeneity in the Choctaw population, the occupancy of a common area, and the necessity to resist common enemies. They preserved perhaps the simplicity of culture existing among all Muskhogean Indians in

times long anterior to the formation of more complicated associations or confederacies.

A special meeting of the Anthropological Society of Washington was held March 25, 1913 in the National Museum, the President, Mr. Stetson in the chair. Professor GEORGE GRAVES MACCURDY read a paper on *Ancient man, his environment and his art.* This paper dealt with the environmental factor in human development. The newly discovered human remains from Piltdown, Sussex, and their significance. Recent finds in the terraces of the Somme Valley. The San Isidro Valley deposits near Madrid. Torralba, a large camp site in the Province of Soria, Spain, where a rude stone industry associated with an ancient fauna has been found. Caves of the Island of Jersey occupied by Mousterian man. Typical caves and rock shelters of southern France: La Quina, La Ferrassia, Placard. The art of the cave man in Spain and France: Altamira, Castillo, La Pasiega, Covalanas, Pindal, Font-de-Gaume, Cap Blanc, Niaux, Gargas, Laussel, Alpera, Cogul. Representations of the human form. La Combe, a cave in the Dordogne excavated last summer by Professor MacCurdy. Tuc d'Audoubert, a Pyrenean paleolithic cavern of great beauty discovered last July; its parietal art and unique figures of the Bison modeled in clay. Paleolithic art in its relation to magic; some of the causes which led to its development and eventually to its decay.

The paper is based largely on first hand observations made during the past summer. The lantern slides reproduce faithfully in color the remarkable paleolithic cavern frescoes. The epochs covered by the paper, beginning with the oldest, are: Eolithic or pre-Chellean, Chellean, Acheulian, Mousterian, Aurignacian, Solutrean, Magdalenian, and Azilian. These are all pre-Neolithic.

A special meeting of the Anthropological Society of Washington was held April 1, 1913, at the National Museum, the President, Mr. STETSON, in the chair.

Dr. J. H. GORE, who returned recently from a visit to the King of Siam, read a paper on *Siamese life and industries* illustrated by lantern slides. He described the Siamese basketry, matting, textile fabrics of silk and other material, also the bronze vessels, silver vessels, and excellent hammered silverware, the method of producing the latter being to fill a silver vessel with sand and hammer in the surface from the outside to form the ground, leaving the decorative human figures in series (beside other ornaments) in high relief. Usually the figures represent some mythological story. Dr. Gore's lantern pictures included farm-scenes, illustrations of games, festivities and elephant-capturing and views of the city of Bangkok, the aquatic human life of its rivers and canals, the palace, imperial crematories, and temples, including a beautiful rock cavern temple.

The chief resources of the country are the teak-wood forests and rice culture, most of the ships-decks of the world being supplied from the

former now managed by an expert forester, while the export of rice is great, about seventy rice mills of modern equipment being operated in Bangkok, besides a large amount of similar work which is done by more primitive methods and appliances throughout the country. The soil is exceedingly fertile in the main valley of the kingdom. There are about eighty miles of good roads around Bangkok and the streets of the city are well made, modern street-car lines running on some of them: but the remainder of the country is practically without roads.

The late king was notable for many enlightened reforms, such as freeing slaves, relinquishing the royal ownership in the land in the favor of those who had been long in occupancy and use of it, waiving the exemption of the royal lands from taxation and compiling and publishing an edition of the Buddhist scriptures, which he supplied to the libraries of the world.

The inhabitants of Cambodia are of stock similar to the Siamese, but are regarded by them as inferior. Their language is akin to the Sanscrit. The human images before their temples are not idols, but for ornament. There is a flame-like upward aspiring tendency in their decorative work. No magical or religious importance is attached to white elephants, so called, which are albinoes, white only in patches; they are regarded as curiosities and as such are given to the king.

The 468th regular and 34th annual meeting of the Anthropological Society of Washington was held on April 15th, 1913, at the National Museum, the President, Mr. Stetson, in the chair.

The minutes of the last preceding annual meeting were read and approved.

Obituary notices were presented as follows: Miss Alice Fletcher for Miss Sarah A. Scull; Mr. F. W. Hodge for Mr. W J McGee; Dr. Lamb for Dr. Robert Fletcher.

The following officers were elected and installed for the ensuing year: President, Mr. George R. Stetson; Vice-President, Dr. John E. Swanton; Secretary, Dr. Daniel Folkmar; Treasurer, Mr. J. N. B. Hewitt; Councillors: Mr. George C. Maynard, Mr. Felix Neumann, Dr. I. M. Casanowicz, Dr. E. L. Morgan and Mr. Francis La Flesche.

Invitations to meetings of the National Academy of Sciences and of the German Anthropological Association were presented and accepted with thanks.

Wm. H. Babcock, *Secretary.*

THE PROCEEDINGS

OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str.. Berlin.

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# JOURNAL

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ASTROPHYSICS.—*The variation of the sun.* C. G. ABBOT, F. E. FOWLE, and L. B. ALDRICH.[1]

In the year 1902 preliminary experiments were begun at Wash ington to determine the solar constant of radiation. About 700 determinations of it have now been obtained, depending on observations at altitudes ranging from sea-level to 4420 meters. As originally devised by Langley we determine spectral energy intensities and atmospheric transmission coefficients for numerous wave-lengths between about $0.30\mu$ in the ultra-violet and $2.5\mu$ in the infra-red, by spectrobolometric observations at high and low sun. The indications of the spectrobolometer are reduced to the standard scale of calories per square centimeter per minute by means of the readings of the pyrheliometer.

At the time when the observations were begun in 1902 there was no satisfactory establishment of the standard scale of pyrheliometry, nor indeed any pyrheliometer which was invariable relatively to itself from year to year. We at first made use of a modification of Tyndall's mercury pyrheliometer. This was improved in 1906 as the copper disk pyrheliometer, which has been in use on Mount Wilson ever since, and which is described in volume 2 of the *Annals of the Astrophysical Observatory.* A still later improvement took place in 1910 with the introduction of the so-called "Silver-Disk Pyrheliometer" which has attained considerable favor, and which is now in use in numerous countries. Neither of these instruments is capable of yielding independently

[1] Published by permission of the Secretary of the Smithsonian Institution.

the standard scale of radiation, but they possess the valuable qualities of simplicity and of being constant from year to year. Beginning with the year 1903 and extending until the end of the year 1912 we have repeatedly devised and experimented with instruments to fix the standard scale of radiation. Three of these instruments (called Water-flow Pyrheliometers Nos. 2 and 3, and Water-stir Pyrheliometer No. 4) have been tested with satisfactory results which are stated in a publication by two of us.[3] We are now satisfied that the measurements made since 1903 can be reduced to the standard scale of radiation to within 1 per cent.

Measurements of the solar constant of radiation were begun at Washington, practically at sea-level, and were continued when favorable opportunities presented themselves from October, 1902, until May, 1907. Measurements were begun on Mount Wilson in California (elevation 1730 meters) in 1905, and have been continued with the exception of 1907 during about six months in the year in each of the succeeding years. Expeditions to Mount Whitney in California, altitude 4420 meters, were made in 1908, 1909, and 1910. Expeditions to Bassour, Algeria, altitude 1160 meters, were conducted in the autumn of 1911 and the summer of 1912. In all 696 complete determinations of the solar constant of radiation have been made, and still others are unreduced. The differences found between the results at different elevations are very small, and seem attributable rather to experimental error or slight atmospheric irregularities than to any difference of elevation. The mean of all these 696 determinations made principally between the years 1905 and 1912 is

**1.932 calories per square centimeter per minute.**

Subject to the possibility that there may exist ultra-violet rays of appreciable intensity beyond the wave-length $0.29\mu$, which are cut off by the absorption of ozone from reaching the earth's surface, we believe that this value represents the intensity of the radiation of the sun as it would be found in space at the earth's mean solar distance for the epoch 1905 to 1912.

[3] See "Smithsonian Pyrheliometry Revised;" Smithsonian Miscellaneous Collections **60**: no. 18. 1913.

In the year 1903 we found indications that the radiation of the sun is not constant from day to day.[3] It has been a main object of the work to ascertain if these apparent variations of the sun are really solar, or are due to some accidental or atmospheric influences not fully eliminated. As early as the year 1910 it had been shown that practically equal solar-constant values were obtained on good days at sea-level, at 1730 and at 4420 meters elevation, and it had been shown that the apparent fluctuations of the solar radiation found on Mount Wilson from day to day marched by regular steps from high to low values and return, not fluctuating wildly as they would have done had they been due to experimental error. Accordingly it seemed from the first consideration (namely that altitude did not appear to affect the results) that the atmosphere was not the cause of the fluctuation; and from the second consideration (namely, that the values marched step by step from high to low or *vice versa*) that it was not an accidental fluctuation. Hence, the most probable conclusion was either that the radiation of the sun is actually variable, or that some meteoric or other matter, by interposition between the earth and the sun, alters the quantity of the radiation received at the earth from day to day. The fluctuations appeared to be of irregular magnitude and period, often ranging through 5 per cent or more, in an interval of seven or ten days.

However probable the result just stated might appear, it could not be fully verified without carrying out the observation simultaneously at two stations widely separated on the earth's surface, so that no local atmospheric influence could be supposed to affect both stations at once. This extension of the work was made possible by the Algerian expeditions of 1911 and 1912. Solar-constant determinations were made nearly simultaneously at Mount Wilson, California, and Bassour, Algeria, separated by about one-third of the circumference of the earth. A difference of time of about eight hours generally occurred between the observations, but inasmuch as the apparent fluctuations of the sun seldom reach 1 per cent in a day, this difference of eight hours seems not much prejudicial to the comparison.

[3] See Astrophysical Journal **19**: 305. 1903.

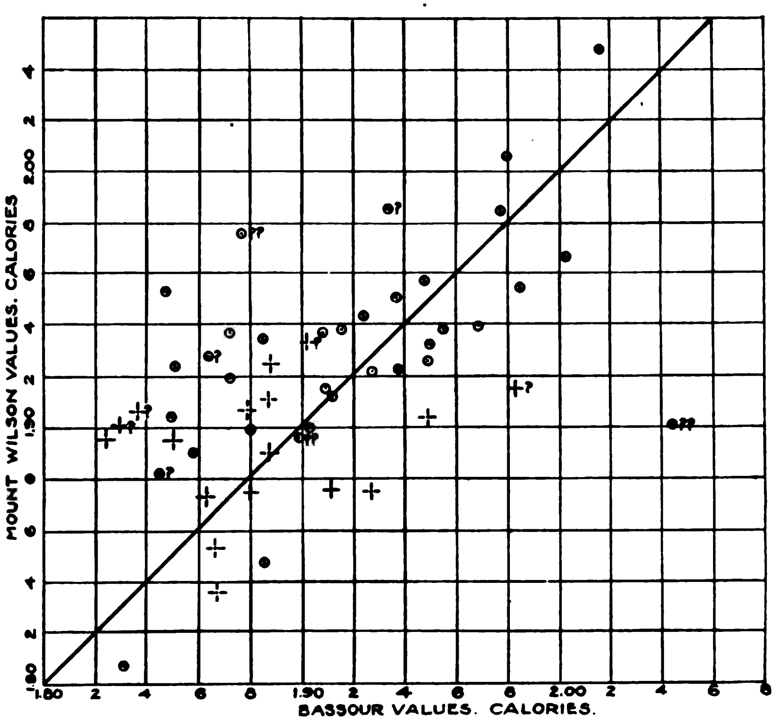
We were somewhat unlucky in our expeditions. In 1911 a box containing the bolometer and other necessary parts was delayed one month in reaching Algeria, so that a long period of good weather in August was lost. Also the months of September, October, and November, 1911, proved less favorable than usual at Mount Wilson and less favorable than had been hoped at Bassour. Thus the number of days in 1911 in which good observations were secured in both places was rather small. In the year 1912, although the sky was generally cloudless, the eruption of the volcano of Mount Katmai in Alaska of June 6 and 7 so filled the sky with haze, both at Mount Wilson and at Bassour, that a great many days of July and August were rendered unsuitable for comparison between the two stations. Thus it occurred that of 75 days in which observations were secured at both stations in the years 1911 and 1912, only 48 were found good enough for satisfactory comparisons of the solar constant values obtained.

For the purpose in view namely, to show whether the apparent fluctuation of solar radiation is due to something outside the earth, it is immaterial whether the days of observation are consecutive or not. It is only required to know whether, if high values are found at Bassour, high values will occur on the same day at Mount Wilson, and, if low values are found at Bassour, low values will be found on Mount Wilson. It matters not whether the days in question be found in one year or another, provided that they be numerous enough to exclude the probability that an agreement, if obtained, is owing wholly to chance.

The accompanying illustration gives the results of all the days found suitable for comparison between Bassour and Mount Wilson. Ordinates are solar constant values as obtained at Mount Wilson, abscissae are solar constant values as obtained at Bassour. Circles represent the results of days of the year 1912, and crosses represent the results of days of the year 1911. If the solar radiation had varied, and all determinations of it had been free from error, the points must all have lain upon the straight line inclined at 45 degrees to the axis. As it is impossible that results shall be entirely free from error, we must expect that the points representing individual days will be well represented by the 45 degree

line if the sun is variable, but will fall uniformily distributed about one point on that line if the sun's radiation is constant. There is no difficulty in deciding that the line and not some single point of the line best represents the results here given.

The variation of the sun shown between the extreme observations amounts to 11 per cent, and many observations unite in




showing a variation of 7 per cent. The average deviation of the separate determinations at Bassour from those of the same days at Mount Wilson is 1.6 per cent.

Hence the average deviation of a single day of solar-constant measurement at one station will be $\left(\frac{1.6}{\sqrt{2}} = \right)$ 1.1 per cent, and the probable error of a single solar-constant measurement at one

station will be 0.9 per cent. Had the condition of the sky in 1912 been free from the haze which prevailed owing to the volcanic eruption of Mount Katmai, we believe the probable error of the separate determinations of 1912 would have scarcely reached 0.5 per cent.

It will be seen that the measurements of 1912 are on the average above those of 1911, at both stations. The difference 1912–1911 is 0.03 calories per square centimeter per minute. This in itself may be regarded as an indication of the variation of the sun depending upon nearly twenty days of observation in 1911 and about thirty days of observation of 1912.

In further study of the variation of the sun we have compared the mean solar-constant values obtained on Mount Wilson for the different months of the years 1905 to 1912 with the monthly values of the sun-spot numbers as published by Wolfer. We find a fluctuation of solar radiation in the sense that when the sun-spot numbers are high the solar radiation is high and *vice versa.*

It is also indicated that when the solar radiation is increased the intensity of the violet and ultra-violet rays of the solar spectrum (as it would be found outside the atmosphere) is increased with respect to the intensity of the red and infra-red.

Again it seems to be indicated that when the solar radiation is high the contrast between the brightness of the centers and edge of the solar disk is greater than normal.

These and other results of this long investigation are published with details in volume 3 of the *Annals of the Astrophysical Observatory* of the Smithsonian Institution, now in press and expected to appear about July 1, 1913. The most important conclusions are as follows:

1. The mean value of the solar constant of radiation for the epoch 1905–1912 is 1.932 calories per square centimeter per minute.

2. An increase of 0.07 calories per square centimeter per minute in the "solar constant" accompanies an increase of 100 sun-spot numbers.

3. An irregular variation frequently ranging over 0.07 calories per square centimeter per minute within an interval of ten days

is established by numerous nearly simultaneous measurements at Mount Wilson, California, and Bassour, Algeria.

4. Indications of two wholly independent kinds incline us to think that these variations of solar radiation are caused within the sun, and not by interposing meteoric or other matter.

PHYSICS.—*The melting points of some refractory oxides.* C. W. KANOLT, Bureau of Standards. To appear in the Bulletin of the Bureau of Standards.

Altho a considerable number of oxides are used as refractory materials, the melting points of but few of them have been determined, and many of the determinations that have been made are quite uncertain. For example, some of the determinations would indicate that lime and magnesia are more fusible than alumina, which can easily be demonstrated to be untrue, for alumina is readily fused in the oxyhydrogen flame, while pure lime and pure magnesia are infusible in it, at least under ordinary conditions.

The principal difficulties encountered in the accurate determination of the melting points are the production of very high temperatures uniform thru a sufficient space and controllable; the supporting of the oxide in the furnace without its contamination by the material used as a support; the avoidance of smoke, which would interfere with the measurement of temperature by an optical pyrometer; and, finally, the accurate measurement of temperature.

The furnace used was an Arsem graphite resistance furnace, with some minor modifications. This furnace was designed to be used with a vacuum, which prevents the oxidation of the graphite and diminishes the heat losses. It was found impossible, however, to melt lime or magnesia in a vacuum, for they are completely vaporized before the melting point is reached. When these oxides were melted, and also in some other cases, the furnace was filled with a non-oxidizing gas, such as hydrogen, under atmospheric pressure.

The temperatures were determined by means of a Morse optical pyrometer of the Holborn-Kurlbaum type, which was sighted ver-

tically downward thru a glass window in the top of the furnace. The carbon-filament pyrometer lamps were calibrated against the following melting points:

| *Material* | *Melting point degrees* |
|---|---|
| Antimony | 630 |
| Copper-silver eutetic | 779 |
| Silver | 960.5 |
| Copper | 1083 |
| Diopside | 1391 |

These materials were melted in graphite crucibles, the pyrometer being sighted into a thin-walled graphite tube inserted in the metal. Heating curves or cooling curves were plotted.

As the temperatures to be measured were far above the working limit of the pyrometer lamps, absorption glasses were interposed between the pyrometer and the furnace. The true temperatures were then found from the apparent temperatures measured thru the glasses, by means of the equation:

$$\frac{1}{T_2} - \frac{1}{T_1} = A$$

where $T_1$ is the absolute temperature of the furnace, $T_2$ is the apparent temperature observed thru the glasses, and $A$ is a constant. The value of $A$ for each glass or combination of glasses used was determined by sighting the pyrometer at a black body held at a constant temperature within the working limit of the pyrometer lamps, and taking readings alternately with and without the interposition of the glass. It was found that a small error might be introduced by the lag of the pyrometer lamp when its temperature was thus changed at short intervals. This was avoided by using two pyrometer lamps, each maintained approximately at one of the temperatures to be measured. A correction was applied for the absorption and reflection of the glass window of the furnace.

It was found that measurements of the same high temperature made with different pyrometer lamps or different absorption glasses were always in satisfactory agreement. As a check upon the work five determinations of the melting point of platinum

were made. The value of this fixed point accepted by the Bureau of Standards is 1755°. The platinum was melted in magnesium aluminate tubes in an iridium furnace, and both heating and cooling curves were plotted. The weighted mean of the five determinations was 1755°, with an average deviation of 5°.

The problem of avoiding smoke when the oxides are not heated in a vacuum has received very little attention in previous work, and is probably responsible for many low results It was found that errors from the presence of smoke could be avoided by introducing into the oxide to be melted a tube of suitable material into which the pyrometer was sighted, and keeping this tube clear by a gentle current of gas. The cooling effect of the gas was found to be quite negligible. With this apparatus it is impossible to see the oxide while it is melting, but as all melting points were determined by heating curves, this is not necessary. All determinations were checked by the examination of samples that had been heated to temperatures slightly below that obtained for the melting point, and also of samples heated slightly above the melting point.

Magnesia was melted in graphite crucibles, for it forms no carbide at high temperatures. It does react with carbon with the formation of carbon monoxide and magnesium vapor, as shown by Watts; but this introduces no contamination into the magnesia. The determinations were made at atmospheric pressure to avoid too rapid vaporization of the magnesia and smoke was avoided by the introduction of a graphite tube thru which gas was blown.

Lime forms carbide rapidly in contact with graphite at high temperatures; graphite is therefore out of the question as a crucible material. Lime was successfully melted in tungsten crucibles with an inner tube of tungsten, thru which hydrogen was blown. Three results in excellent agreement were obtained in this way, but the tungsten usually melted as soon as the lime had melted. This was probably the result in part of contamination of the tungsten by carbon, but the tungsten also appeared to be contaminated by contact with the fused lime, perhaps with the formation of metallic calcium. This led to the suspicion that the

melting point of the lime might be changed by the presence of the tungsten. To confirm the results another method was used. A tube made of lime was inserted into the furnace, being supported by the upper end, which was at a low temperature, while the lower end extended into the hot part of the furnace. The tube was kept free from smoke by a gentle current of hydrogen, which passed out thru a small oblique opening at the bottom. The pyrometer was sighted down the tube and a heating curve was plotted. Determinations made in this way were in close agreement with those made in tungsten crucibles. It is believed that this method will be very useful with other substances for which it is difficult to find crucible materials.

Alumina can be melted in a vacuum high enough to avoid all smoke without vaporizing so rapidly as to cause serious trouble. Determinations were made in this way with both tungsten and graphite crucibles. When the alumina was melted in graphite it did not form appreciable carbide until after it had completely melted and the melting point had been determined; and then the contamination was not rapid. The results with graphite crucibles and tungsten crucibles were in agreement. Determinations were also made at atmospheric pressure with the apparatus constructed for magnesia, the smoke being removed by a current of gas. These results agree with the others.

Chromium oxide was melted in tungsten crucibles in a vacuum. When melted in graphite it is rapidly reduced.

The results are summarized in the following table:

| OXIDE | MELTING POINT CENTIGRADE | NUMBER OF DETERMINATIONS | AVERAGE DEVIATION |
|---|---|---|---|
| | *degrees* | | *degrees* |
| $MgO$ | 2800 | 6 | 13 |
| $CaO$ | 2570 | 5 | 3 |
| $Al_2O_3$ | 2050 | 8 | 4 |
| $Cr_2O_3$ | 1990 | 5 | 6 |

PHYSICS.—*New modified thermoelectric methods in calorimetry.*
WALTER P. WHITE. Geophysical Laboratory. Communicated by A. L. Day.

In the common calorimetric method, the "Method of Mixtures," the work of the last five years has shown that the error due to heat loss from the calorimeter into the air, once thought to be an unconquerable foe to accuracy, is, in fact, ordinarily quite negligible. With a proper installation, the attainment of very high precision, to 0.1 per mille or better, requires merely sufficient precision in the temperature measurement. Such precision has been attained for ordinary systems by using electric thermometers. It remains to make the operation of these thermometers as simple and as free as possible from experimental precautions and corrections, to facilitate the attainment of unusual precision where this is desirable, and to take advantage of the facilities which the electrical system offers for making various measurements such as could not be attempted with the older mercury thermometers.

For a variety of measurements the thermoelectric thermometer system is especially well adapted, as has already been shown elsewhere. The present paper deals with the securing of certainty and high precision by means of the thermoelement. The essential feature of the methods is to use, around the "cold junction" of the thermoelement, in place of an ice bath, a body at nearly the same temperature as the calorimeter. The smallness of the electrical quantity to be measured then gives to the temperature measurement extraordinary precision combined with extraordinary ease. These methods, accordingly, while specially advantageous for precision in determining very small heat quantities, are in nearly all cases among the best in convenience and certainty.

Determinations of great delicacy have already been made on this principle, especially in Nernst's laboratory. In these the other body was a twin calorimeter. If the two calorimeters are alike, the external temperature and its changes affect both alike, and hence have but a slight effect upon the thermoelement read-

ing which measures the difference in the temperatures of the two. It is thus possible to proceed almost as if the external temperature had no effect at all. This has been claimed as a second great advantage of the twin method. A complete jacket, however, is much more effective in this direction, and, on the other hand, there is a cooling correction error peculiar to the twin method. It arises whenever the two calorimeters are not exactly alike, and can easily be shown to be $(K_a - K_b) \cdot (\theta_b - \theta_j)$ where $K_a$ and $K_b$ are the cooling rates of the two calorimeters, $\theta_b$ and $\theta_j$ the temperatures of the comparison calorimeter and of the jacket, respectively. This error is nearly eliminated if three observation periods are run (as in the usual Pfaundler Method with one calorimeter), but it can be more easily avoided by making the temperature difference, $\theta_b - \theta_j$, small, say below 0.2°. Only two observation periods are then needed.

The trouble of the temperature adjustment is largely or wholly avoided by either of two schemes, both of which utilize the low cooling rate of a vacuum-jacketed flask, which is used for the comparison calorimeter. In one scheme, a regulator keeps the jacket temperature constant. The flask is then constant to a very high degree of precision (easily to 0.0001°) without any further attention whatever. This has been called the *constant comparison body method.*

The other scheme avoids the regulator. A specially adjusted (shunted) thermoelement is used in determining the cooling correction. The two unlike calorimeters can then be operated as easily and conveniently as if they were twins, but the temperature adjustment is so much less exacting as to be almost negligible. This has been called the *compensated calorimeter method.* A combination of the two methods can be made at will, either temporarily or permanently, involves no difficulties, and reduces precautions and corrections to a very low minimum.

The gain in simplicity and ease of construction by using vacuum-jacketed bottles is evident. An effective and particularly simple way of using the bottle is to immerse it wholly in the jacket water, with an inverted cap over it containing air. A tube running down thru the cap allows the thermoelement to be

inserted or withdrawn at will without escape of air. The jacket water surrounding the thermoelement above the cap insures definite conditions as to temperature.

The best of these methods call for a complete inclosure by the jacket, but this is almost indispensable in any calorimetry of precision, and can be easily obtained. For instance, the calorimeter chamber may be a cylindrical pot, suspended in a commercial paper tub. The cover is a square box, filled with water, and closed, save for two pipes which project downward thru the surface of the water below and so provide for a complete circulation. The protection against evaporation of the jacket water which is usually necessary for precision work is very easily secured by a layer of paraffin cast on the surface of the water. This layer can of course be easily sawed or recast. By a suitable and rather evident arrangement of thermoelements, any of these schemes can be operated with the two calorimeters in two separate jackets. This procedure is necessary in the case of adiabatic methods. A precision of 0.0001° is very easily reached, under fair conditions, with a thermoelement of 24 couples. Elements of 8 couples, ordinarily precise to 0.0003°, are so very compact that the use of anything smaller will rarely be advisable.

Work with these methods has emphasized the desirability of providing, not only abundant thermometric sensitiveness, but, especially, a thoro and uniform jacket inclosure, with vigorous stirring thru wide openings. The trouble required for these precautions is slight in itself, and is insignificant compared to that likely to be entailed by trying to dispense with them.

The requirements of these methods in the way of auxiliary electrical apparatus (potentiometer, etc.) are unusually simple and inexpensive, but are nevertheless exacting in certain directions. Elaborate apparatus and methods, admirable for other kinds of work, may fail here, tho success is easy by appropriate arrangements. A revised account of the essential requirements is in preparation. The great advantage of these methods is in the ease and precision of the temperature measurement. Otherwise, they present disadvantages, which, however, are evidently slight, and far outweighed by the advantages.

PHYSICS.—*On the absorption of light in heterogeneous media.*
P. G. NUTTING. Eastman Kodak Company. Rochester, N. Y.

Photographic density depends upon the size and number of the imbedded silver grains and to a slight extent upon their form and distribution as well. The mathematical problem of relating density to grain is obviously to be treated by probability theory rather than by infinitesimal analysis. The solution here presented will be of interest to students of the theories of radiation and of entropy in discontinuous systems, in that it is a much simpler problem treated by similar probability methods.

Suppose snowflakes of a given size to be falling with perfect irregularity upon a surface. When a given number per unit area have fallen, what will be the mean relative areas covered and uncovered? In the plate grain problem as in the snowflake problem, the distribution is completely irregular, but in a volume instead of a plane. The grains are contained in a layer of the order of 10 to 20$\mu$ thick and are themselves 0.5 to 3$\mu$ in diameter, irregular in outline and fairly uniform in area in any one plate. The grains are not crystals, but aggregates of finely divided silver resembling platinum black or soot, of very high absorbing and low reflecting power. This reflecting power has not yet been directly determined, but estimates based on scattering make it well under 2 per cent. In the following discussion both *reflection* and *diffusion* are neglected, tho both may be readily entered in the equations.

Consider the absorbing body divided into layers about 1 grain thick, parallel with the surface, so that there will be but a negligible amount of overlapping of grains in any one layer. That certain grains lie partly in two successive layers is of no consequence, since in the equations they are counted but once in the layer in which their greater bulk lies. In the first layer let there be $n_1$, grains per unit area and let $a_1$ be their average projected area. Then the probability of a ray of light being stopped by this layer is the ratio of the covered to the total area, or as $n_1 a_1$ to 1. Similarly the probability of a ray passing the first layer is

$1 - n_1 a_1$. In other words the absorption and transmission *coefficients* are respectively the *probabilities* of being stopped and of being passed.

In the second layer let the corresponding quantities be $n_2$ and $a_2$; in the third $n_3$ and $a_3$ and so on. For brevity call the product $n_1 a_1 \equiv A_1$, etc. Now the only manner in which a ray may pass thru all layers is to pass each layer separately hence the probability of passing all layers is the continued product

$$(1 - A_1)(1 - A_2) \quad . \ . \ . \ . \quad (1 - A_m) \equiv T_m \qquad (1)$$

of the probabilities of passing each separate layer. This is the *transparency* of the whole sheet. The corresponding absorption $B_m$ is the complementary quantity

$$B_m = 1 - T_m \qquad (2)$$

It may be noted that the absorption of the whole is not the product $(A_1 A_2 \quad . \ . \ . \quad A_m)$ of the probabilities of absorption in the various layers since the action is not alike in all layers, a ray may be passed by several layers to be stopped in another. The above product $(A_1 A_2 \ . \ . \ . \ A_2)$ is the probability of possible stoppage in *all* layers, i.e., the probability per unit area of a continuous train of grains lying one behind the other, thru all the successive $m$ layers. In fact, if the value of $T_m$ in (1) be written in (2), multiplied out and grouped according to the number of $A$'s multiplied together, then each group gives the probability of 2, 3 . . . $m$ grains overlapping.

In the special case of all layers alike in number and size of grain, the transparency of all $m$ layers will be

$$T_m = (1 - A)^m \qquad (3)$$

since in (1) $A_1 = A_2, = \ . \ . \ . \ = A_m$. This corresponds to *Beer's Law* in ordinary optics.

Photographic *density* $D$ has of late years been precisely defined by the relation

$$D = -\log_{10} T \qquad (4)$$

$T$ being the transparency in the sense used above. The value of $T_m$ in either (1) or (3) may be substituted in (4) according to

conditions. Equations (1) and (4) give the general relation sought between density and the number, size and distribution of grain.

In all ordinary practice the size and distribution of grain thruout the film is so uniform that (3) gives a very close approximation indeed. In this case.

$$D = -m \log (1 - A). \tag{5}$$

If further $A$ is so small that the overlapping of grains is negligible, as is the case with low and medium densities,

$$D = m A = m n a \tag{6}$$

The ratio of the mass of reduced silver per unit area to the density (4) is an important quantity, the so-called *photographic constant.*

Now the film is $m$ layers deep, hence $m\,n = N$ is the whole number of grains per unit area. Mass of silver ($M$), per unit area is then proportional to $N$ and to the average volume of the grains,

$$M = c N a^{3/2}, \tag{7}$$

the constant $c$ involving the specific gravity of the silver and certain numerical factors.

The photographic constant ($P$), defined as mass of silver per unit area per unit density, is then

$$P = \frac{M}{D} = \frac{cNa^{3/2}}{Na} = c\sqrt{a} \tag{8}$$

if the overlapping of grains is negligible, or is

$$P = -\frac{cNa^{3/2}}{\Sigma \log (1 - na)} \tag{9}$$

without assumptions as to overlapping or uniformity of grain thru the film.

From these equations it appears that $P$, to a first approximation, is independent of $N$ and hence of exposure and development, but that it will vary among different brands of plates in proportion to the mean diameter of grain. The first of these conclu-

sions is a well known experimental fact. $P$ is of the order of 10 mg. of silver per square decimeter of film, per unit density. The relation between $P$ and size of grain has not yet received experimental confirmation, tho $P$ is known to vary in different kinds of plate.

In the following table are numerical values calculated for different photographic densities.

TABLE I

| $D$ | $T$ | $1-A$ | $A$ | $10\ A$ |
|---|---|---|---|---|
| 5 | 0 00001 | 0.316 | 0.684 | 6.8 |
| 3 | 0 001 | 0.501 | 0.499 | 5.0 |
| 2 | 0.010 | 0.631 | 0.369 | 3.7 |
| 1 | 0.100 | 0.794 | 0.203 | 2.1 |
| 0.7 | 0.200 | 0.851 | 0.149 | 1.5 |
| 0.5 | 0.316 | 0.891 | 0.109 | 1.1 |
| 0.2 | 0.631 | 0.955 | 0 045 | 0.45 |
| 0.1 | 0.794 | 0.977 | 0.023 | 0.23 |

$T$ is the fraction of the l'ght transmitted by the entire thickness of film, $1 - A$ is the corresponding transmission of any single layer 1 grain deep while $A$ is the fraction absorbed, on an average, in any single layer. The final column, $10\ A$, is what the absorption of a film 10 grains deep (an ordinary film) would be if each grain were fully effective. Thus, for unit density, the transparency is 10 per cent, the absorption of a single layer 20 per cent and there are present 2.1 times as many grains as would completely cover a surface.

Taking the particular case of unit density and $A_1 = 20$ per cent (0.20) and computing the absorption of the first $n$ layers by the formula

$$B_{1\ldots n} = 1 - T_n = 1 - (1 - A)^n,$$
$$B_1 = A = 0.20,\ B_{1,2} = 2A - A_2 = 0.4 - 0.04 = 0.36$$

that is, in the first two layers 36 per cent is covered and 4 per cent of this covered twice. In the first three layers

$$B_{1..3} = 3A - 3A^2 + A^3 = 0.60 - 0.12 + 0.008 = 0.488$$

the probability of overlapping is 0.12, of triple overlapping of grains is 0.008. Tabulating for *ten* layers,

TABLE II

| $n$ | $T_n$ | $B_n$ | $\Delta B_n$ | $A^n$ | $_nP_{10}$ |
|---|---|---|---|---|---|
| | | | per cent | | |
| 1 | 0.794 | 0.206 | | 0.21 | 2.06 |
| 2 | 0.633 | 0.367 | 16.1 | 0.04 | 1.80 |
| 3 | 0.501 | 0.499 | 13.2 | 0.008 | 0.96 |
| 4 | 0.398 | 0.602 | 10.3 | 0.0016 | 0.336 |
| 5 | 0.316 | 0.684 | 8.2 | $0.0_{3}32$ | 0.080 |
| 6 | 0.251 | 0.749 | 6.5 | $0.0_{4}64$ | 0.013 |
| 7 | 0.200 | 0.800 | 5.1 | $0.0_{4}13$ | 0.0017 |
| 8 | 0.159 | 0.841 | 4.1 | $0.0_{5}26$ | $0.0_{3}12$ |
| 9 | 0.126 | 0.874 | 3.3 | $0.0_{6}51$ | $0.0_{5}52$ |
| 10 | 0.100 | 0.900 | 2.6 | $0.0_{6}10$ | $0.0_{6}10$ |

The second and third columns give respectively the *transparency* and *absorption* of the first $n$ layers. The fourth column gives the increment of absorption due to the $n$th layer. The fifth column gives the probability of $n$ grains overlapping in $n$ layers. The last column gives the probability of $n$ grains being in line in all ten layers, it is $A^n$ 10! / N! (10-$n$)!

RADIOTELEGRAPHY.—*Difference in strength of day and night signals in radiotelegraphy.* L. W. AUSTIN, U. S. Naval Radiotelegraphic Laboratory.

The first explanation, given of the difference in strength of day and night signals after the discovery of the phenomenon by Marconi, was that sunlight, by ionizing the air around the sending antenna, produced energy losses which resulted in a decrease in the strength of the received signals. This idea has long been abandoned as affording a full explanation of the phenomenon. Recent observations between the Arlington station and the station at the Bureau of Standards, 8 kilometers apart, show that if the effect exists at all it is a matter of not more than 1 or 2 per cent.

At a later period it was supposed by many workers in radio-

telegraphy that the increase in strength of signals at night was caused by the decrease in an absorption in the upper conducting layers of the atmosphere after the ionization due to the sunlight and possible cathode rays from the sun had ceased.

The data accumulated by the U. S. Navy Department during the last three years appear to make this explanation improbable for the two following reasons: (1) It is known that in certain regions and at certain wave lengths the ground absorption is more than twenty times as great as would be the case if the signals were sent over salt water. The sun's rays can hardly be thought to affect the losses in the earth to any extent, yet on some nights these waves travel across the same region, reaching the receiving station with as great strength as would have been the case if there had been no absorption at all.[1] (2) Observations on undamped oscillations from the arc have shown that at night there is a selective strengthening and weakening of the signals with changing wave length. For example, during the recent tests of the arc at Arlington, it was found that when the night signals at the receiving station were faint at the regular wave length of 4100 meters, changing to 3950 meters would almost invariably bring them in with greatly increased strength and *vice versa*. This suggests the light and dark interference bands of optics and, as Dr. De Forest has suggested,[2] the phenomenon may be explained by the interference of a set of waves traveling along the earth's surface with another set which has been reflected from the conducting layers of the upper atmosphere. Calculations show that the height of the reflecting surface would be from 40 to 60 miles, which are very probable values for the point at which conductivity would begin. This phenomenon has been observed so constantly in the work with the arc that there can be absolutely no doubt of its existence. The fact that it has not been observed in the case of spark waves is due partly to the fact that spark apparatus is generally not changed in wave length by such small

[1] In many well authenticated cases signals have been received with more than twice the strength which the simple Duddell and Taylor law would have indicated.

[2] Proc. Inst. Radio Engineers **1**: 37. 1913.

percentage steps, and partly to the shortness of the wave trains which would not permit the direct and deflected trains to overlap for any considerable difference of path.

These facts indicate that the greater strength of night signals is probably due not to a decrease in absorption, but rather to additional energy which reaches the receiving station by reflection. This explanation would involve the idea that at night the upper atmosphere becomes stratified in such a way that at some given height differing at different times, there is a sufficiently sudden change in conductivity to permit reflection. It is conceivable that this stratification is broken up in the day time either by vertical convection currents, or by the more or less irregular ionization produced by the ultra violet rays or cathode particles from the sun.[3]

It is certain that the difference between night and day signals is much less at long waves than at short, but the observations on the Clifden signals ($\lambda$ about 7000 meters) at Brant Rock (2460 miles) and at Arlington (2840 miles) do not agree with the observations of Marconi at Glace Bay that the day signals are equal to or better than those at night.[4] At Brant Rock during the autumn and winter the received current from Clifden thru 25 ohms resistance was in general about $35.10^{-6}$ amp. in the day time, rising at times to $55.10^{-6}$ amp., while at night the current frequently amounted to more than $100.10^{-6}$ amp. In summer the signals were always faint and much of the time inaudible in the day time, varying probably between $7.10^{-6}$ and $12.10^{-6}$ amp. Night signals were much louder, no exact measurements being made on them. The observations on Clifden at Arlington agree qualitatively with the Brant Rock results.

[3] The difference in summer and winter day signals at great distances perhaps indicates that reflection plays some part even in the day time.

[4] It is conceivable that the directive receiving antenna at Glace Bay may have an influence on the phenomenon.

METALLOGRAPHY.—*Preliminary note on the critical ranges, A3 and A2, of pure iron.* G. K. BURGESS and J. J. CROWE, Bureau of Standards.

In view of the recent publication by Professor Carpenter of his very interesting results[1] on this subject and considering its theoretical importance, we deem it advisable at this time to give a brief account of some preliminary observations taken in 1911 and 1912 on the location of the critical ranges in pure iron both on heating and cooling. We had intended deferring publication until results were ready on a specially pure sample of iron prepared here by Mr. J. R. Cain. Since, however, with five samples of iron of the same order of purity as the single one used by Professor Carpenter (99.97 per cent Fe) we are not able to reach the same conclusion he does, namely, "that were it possible to remove the last traces of impurity, iron would cease to show even these faint indications of Ar2," it may be of interest to put on record now some of the results so far obtained. Cooling and heating curves of five samples of electrolytic iron have been taken *in vacuo*, three samples being separate preparations in the form of cathode plates from Prof. C. F. Burgess of Wisconsin; and two samples remelted by us *in vacuo* to remove gases, one prepared by the Langheim-Pfanhauser A. G. furnished by Dr. H. Goldschmidt and one a sample of the C. F. Burgess iron. The samples weighed from 21 to 31 grams.

Two methods of locating the critical ranges were used simultaneously, requiring two observers. The first was the Osmond inverse-rate method, times being recorded to 0.1 second on a cylindrical chronograph and temperatures taken in steps of 2°C. by means of a Diesselhorst potentiometer.

The second was the Roberts-Austen differential method with a platinum neutral and reduced by Rosenhain's derived differential method. The plotted curves should be strictly similar in shape, and in practice, unless something is the matter, they are similar.

Using a specially designed liquid rheostat, it was possible to

[1] H. C. H. Carpenter, The critical ranges of pure iron. Iron and Steel Institute, May, 1913.

PRELIMINARY OBSERVATIONS ON CRITICAL RANGES OF IRON

*Beginning*

| SAMPLE | | $Ac1$ | $Ac2$ | $Ac3$ | $Ar3$ | $Ar2$ | $Ar1$ | NUMBER OF OBSERVATIONS | DATE |
|---|---|---|---|---|---|---|---|---|---|
| C. F. Burgess | No. 1 | | 768 | 904 | 902 | 774 | | 4 | 7/25–28/1911 |
| | No. 2 | 698? | 767 | 909 | 912 | 778 | | 6 | 11/ 8–13/1911 |
| | No. 3 | | 737? | | 903 | 774 | | 5 | 11/21,12/4/1911 |
| | No. 3 remelted in vacuo | 692? | 735? | 917 | 911 | 780 | | 7 | 7/19/,10/22/1912 |
| Langheim-Pfanhauser | | | | 919 | 917 | 855? | | 7 | 8/14–29/1912 |
| Approximate Means | | | 765 | 910 | 909 | 775 | | | |

*Maximum*

| SAMPLE | | $Ac1$ | $Ac2$ | $Ac3$ | $Ar3$ | $Ar2$ | $Ar1$ | NUMBER OF OBSERVATIONS | DATE |
|---|---|---|---|---|---|---|---|---|---|
| C. F. Burgess | No. 1 | | 789 | 934 | 895 | 758 | | 4 | |
| | No. 2 | 704? | 789 | 924 | 901 | 764 | 703? | 6 | |
| | No. 3 | | 778 | 920 | 897 | 769 | ? | 5 | |
| | No. 3 remelted in vacuo | ? | 774 | 921 | 908 | 775 | | 7 | |
| Langheim-Pfanhauser | | | 774 | 922 | 912 | 775 | | 7 | |
| Approximate Means | | | 781 | 924 | 903 | 768 | | | |

PRELIMINARY OBSERVATIONS ON CRITICAL POINTS OF IRON—Continued

*End*

| SAMPLE | | Ac1 | Ac2 | Ac3 | Ar3 | Ar2 | Ar1 | NUMBER OF OBSERVATIONS | DATE |
|---|---|---|---|---|---|---|---|---|---|
| C. F. Burgess | No. 1 | | 814 | 948 | 874 | 724 | | 4 | |
| | No. 2 | 730? | 806 | 933 | 887 | 720? | 682? | 6 | |
| | No. 3 | | 782? | 933 | 874 | | | 5 | |
| | No. 3 remelted in vacuo | | 783 | 934 | 896 | 756 | | 7 | |
| Langheim-Pfanhauser | | | 783 | 934 | 901 | 744 | | 7 | |
| Approximate Means | | | 795 | 935 | 890 | 740 | | | |

| ANALYSES | C. F. BURGESS NO. 1 | LANGHEIM-PFANHAUSER |
|---|---|---|
| | *per cent* | *per cent* |
| S | 0.00 | 0.00 |
| Si | 0.013 | 0.00 |
| P | 0.004 | 0.007 |
| Mn | 0.00 | 0.00 |
| C | 0.012 | 0.00 |
| Cu | | 0.008 |
| H | 0.072 | ? |

adjust for a practically constant rate of heating and cooling over the whole temperature range, 500° to 1100°C. Measurements were taken at rates ranging from three seconds per degree to thirty-six seconds per degree with no considerable effect upon the location or magnitude of the critical ranges. The heating of the furnace was by alternating current from a motor generator run from a storage battery. The results are shown in the accompanying table; the analyses were furnished by Prof. C. F. Burgess and Dr. H. Goldschmidt. It will be noted that for the remelted samples the maxima for Ac2 and Ar2 are identical in position. The plotted curves show Ac2 as pronounced as Ar2 for all the samples. A2 and A3 appear to be different in kind, but the discussion of this subject we prefer to defer until more complete data and check analyses are obtained.

It should also be noted that in 1909, A. Müller[2] published a careful study of the critical ranges of electrolytic iron finding Ac2 = 770°, Ar2 = 763°, Ac3 = 917° and Ar3 = 894°.

[2] A. Müller, Über die Darstellung des Elektrolyteisens, dessen Zuzammensetzung und thermische Eizenschaften. Metallurgie 6: 145. 1909.

## ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

METEOROLOGY.—*Hurricanes of the West Indies.* OLIVER L. FASSIG. Weather Bureau Bulletin **10**: pp. 28, pls. 25. 1913.

The early completion of the Panama Canal makes the present appearance of a good bulletin on the hurricanes of the West Indies peculiarly timely, and the one under consideration fully meets the needs of all who are likely to be interested in this subject. The text is divided as follows: (1) Hurricane areas and hurricane tracks; (2) Frequency of hurricanes; (3) Progressive movement of hurricanes; (4) Duration and intensity of hurricanes; (5) Hurricanes, cyclones, and typhoons; (6) Signs of an approaching tropical cyclone; (7) The hurricane of August 7–20, 1899; (8) Origin of tropical cyclones. The chief feature of the bulletin is its excellent colored charts, which tell at a glance practically the whole hurricane story. W. J. HUMPHREYS.

METEOROLOGY.—*On the physics of the atmosphere.* W. J. HUMPHREYS. Journal of the Franklin Institute. **175**: 207–244. 1913.

In this article a number of physical phenomena of the atmosphere are described and their explanations given. Such as: (1) Vertical temperature gradients as determined by sounding balloons; (2) Composition of the atmosphere at various elevations; (3) Density of the atmosphere at different levels; (4) The nature and cause of the isothermal region; (5) The origin and the climatic effects of the permanent centers of high pressure on the oceans; (6) The structure of the wind, including wind layers, gusts, and cases of violent vertical convection; (7) The origin of thunder-storm electricity. There are also thirteen illustrations that make it easier for the reader to follow the text. W. J. H.

CLIMATOLOGY.—*Two climatic cross-sections of the United States.* ROBERT DE C. WARD. Monthly Weather Review **40**, 1909–1917. 1913.

Professor Ward had the good fortune to take the whole of the 13,000 mile "Transcontinental Excursion of the American Geographical Society," August 22 to October 18, 1912, and had therefore an unusual opportunity of studying at first hand the effects of the numerous climates of this country on topography, plant growth, and human industry. All these he describes in an article that follows the excursion up the Hudson, along the Great Lakes, thru the Bad Lands, among the Geysers, down the Grand Coulée, over the wheat fields, orchards and vineyards of Washington, Oregon and California, across the Sierras, along the old beaches of Lake Bonneville, among the mountains and down the canyons of Colorado, thru the wonderful scenery of Arizona and New Mexico, down the Mississippi, across the southern Appalachians, and along the Piedmont Region by way of Washington, D. C., back to New York. Every climatic section of the United States was visited on this trip, and to each Professor Ward has given its due share of attention.

W. J. HUMPHREYS.

CHEMISTRY.—*The action of potassium amide on cupric nitrate in liquid ammonia solution.* EDWARD C. FRANKLIN. Hygienic Laboratory. Journal American Chemical Society, **34**: 1501. 1912.

Instead of giving a precipitate of cuprous amide as might be expected, cupric nitrate in solution in liquid ammonia reacts with potassium amide to form ammonated cuprous nitride in accordance with the equation $3Cu(NO_3)_2 + 6KNH_2 = Cu_3N.nNH_3 + 6KNO_3 + (4\text{-}n)NH_3 + N$. When heated *in vacuo* to laboratory temperature the precipitate loses ammonia and is converted into cuprous imide, $Cu_2NH$. At higher temperatures cuprous imide is converted into cuprous nitride, $Cu_3N$.

The product of the general formula $Cu_3N.nNH_3$, dissolves in liquid ammonia solution of potassium amide to form a solution from which well crystallized specimens of a colorless salt of the compound represented by the formula, $CuNK_2.3NH_3$, have been obtained. This compound has been named potassium ammonocuprite for the reason that it obviously occupies a position in the ammonia system of acids, bases and salts entirely similar to that which the more familiar zincates, aluminates, plumbites, etc., occupy in the water system.

Potassium ammonocuprite with three molecules of ammonia of crystallization, or triammonated potassium ammonocuprite, readily loses

successively two molecules of ammonia to form the diammonated and monoammonated salts of the respective formulas $CuNK_2.2NH_3$ and $CuNK_2.NH_3$. E. C. F.

CHEMISTRY.—*Potassium ammonotitanate.* EDWARD C. FRANKLIN and THOMAS B. HINE. Journal of the American Chemical Society **36**: 1497. 1912.

Treated with liquid ammonia titanium tetrabromide undergoes ammonolysis and is converted into an ammonobasic titanium bromide of the formula $N \equiv Ti-Br$. When this basic salt, or nitride bromide, is brought into contact with liquid ammonia solution of potassium amide a reaction takes place which results in the formation of a compound of the formula $N \equiv Ti-NHK$ which receives the name potassium ammonotitanate. The two reactions are represented by the equations

$$TiBr_4 + 4NH_3 = N \equiv Ti-Br + 3NH_4Br \quad \text{and}$$
$$N \equiv Ti-Br + 2KNH_2 = N \equiv Ti-NHK + KBr.$$

The results of this investigation show that just as titanium bromide undergoes hydrolysis in contact with water and just as the product of hydrolysis may be made to react with potassium hydroxide to form potassium aquotitanate so similarly the bromide undergoes ammonolysis in contact with liquid ammonia and in presence of an excess of the ammonobase, potassium amide, it is converted into a potassium ammonotitanate. E. C. F.

CHEMISTRY.—*The action of potassium amide on thallium nitrate in liquid ammonia solutions.* EDWARD C. FRANKLIN. Hygienic Laboratory. Journal of Physical Chemistry **16**: 683. 1912.

The black precipitate of thallous nitride, formed by the interaction of liquid ammonia solutions of potassium amide and thallium nitrate in accordance with the equation, $TlNO_3 + 3KNH_2 = Tl_3N + 3KNO_3 + 2NH_3$, dissolves in potassium amide solution to form potassium ammonothallite. The salt thus formed separates from sufficiently concentrated solutions in the form of beautiful yellow crystals of the composition represented by the formula $TlNK_2.4NH_3$. The reaction between thallium nitride and potassium amide is strictly analogous to that which takes place when zinc oxide, for example, dissolves in aqueous solution of potassium hydroxide. Potassium aquozincate is formed in the latter case, potassium ammonothallite in the former. The salt readily loses ammonia to form successively the products represented respectively by the formulas $TlNK_2.2NH_3$ and $TlNK_2.1\frac{1}{2}NH_3$.

Mixed crystals or isomorphous mixtures varying in composition from that of pure potassium ammonothallite to that of a product represented by the formula $TlNK_2.4NH_3.3.6KNH_2$ have been obtained from liquid ammonia solutions of potassium ammonothallite containing an excess of potassium amide. E. C. F.

PALEONTOLOGY.—*Cambrian Brachiopoda.* CHARLES D. WALCOTT. Monographs of the U. S. Geological Survey **51**. Part I, text, pp. 872; Part II, pls. 104, pp. 363. 1912.

This monograph describes 44 genera, 15 subgenera, 477 species, and 59 varieties of Cambrian Brachiopoda, and 3 genera, 1 subgenus, 42 species, and 1 variety of Ordovician Brachiopoda. Of the Cambrian forms, 10 genera, 2 subgenera, 21 species, and 1 variety persist into the Ordovician.

In this paper the Brachiopoda are treated in three ways—historically, geologically, and zoologically. Historically the treatment comprises (1) a bibliography and (2) a table of synonymic reference, giving a completely cross-referenced list of described species with the present generic and specific reference of each. Geologically the distribution of the Brachiopoda is considered under the following headings: (1) General geographic and stratigraphic distribution; (2) detailed geographic distribution; (3) detailed stratigraphic distribution; (4) habitat; and (5) fossil localities. Zoologically the discussion covers (1) the physical characters of the Brachiopoda; (2) their distribution; (3) their evolution; and (4) their classification. Lastly come the detailed descriptions of genera and species and the illustrative plates. P. V. ROUNDY.

ZOOLOGY.—*On a collection of recent Crinoids from the waters about Ireland.* AUSTIN H. CLARK. Department of Agriculture and Technical Instruction for Ireland, Fisheries Branch; Scientific Investigations, 1912, no. IV, pp. 1–5. 1913.

The collection upon which this report is based was brought together by the Irish fishery cruiser *Helga* while working in the seas to the west and north of Ireland; the description of a single specimen taken in the Faeroe Channel by Dr. Wolfenden's yacht *Silver Belle* is also included.

Though small, the collection is of very considerable interest because four of the eight species represented are new to the coasts of the British Islands, one of these representing a genus heretofore known, in the Atlantic basin, only from the Caribbean Sea.

The eight species are: *Antedon petasus* (Düben and Koren) (not

previously reported from Ireland); *Leptometra celtica* (Barrett and McAndrew); *Hathrometra prolixa* (Sladen) (Faeroe Channel); *Trichometra hibernica*, sp. nov. (related to a species occurring off Newfoundland); *Trichometra delicata* (a species described in 1911 from the Bay of Biscay); *Pentametrocrinus atlanticus* (not hitherto known north of the Bay of Biscay) *Atelecrinus helgae*, sp. nov. (related to the Caribbean *A. balanoides*, and the first species of the genus to be discovered in the east Atlantic); and *Rhizocrinus lofotensis*. A. H. C.

BACTERIOLOGY.—*Further attempts to transmit poliomyelitis thru the agency of the stable fly (Stomoxys calcitrans).* JOHN F. ANDERSON, Surgeon, U. S. Public Health Service, Director Hygienic Laboratory, and WADE H. FROST, Passed Assistant Surgeon, U. S. Public Health Service. Public Health Reports, 1913.

In an experiment conducted in October, 1912, we were able to infect monkeys with poliomyelitis by exposing them to the bites of several hundred *Stomoxys*, which were allowed, at the same time, to feed on monkeys inoculated intracerebrally with poliomyelitis virus. From the date of that experiment up to February, 1913, we have carried out a number of additional experiments designed to throw light upon the conditions necessary for the experimental transmission of poliomyelitis thru *Stomoxys calcitrans*. The flies used in our later experiments have been, in part, captured in the vicinity of the Hygienic Laboratory and, in part, bred in the laboratory. In a considerable number of our experiments we have undertaken to simulate summer conditions by maintaining a temperature of 75° to 85° F.

In these experiments monkeys inoculated with poliomyelitis have been exposed to large number of *Stomoxys* at various stages of their incubation period and during the period of developed symptoms. Fresh monkeys have been exposed to these same flies simultaneously with the inoculated monkeys and at various intervals thereafter. *Stomoxys* fed on defibrinated blood drawn from inoculated monkeys in all stages of the incubation period of the disease and others fed on mixtures of normal monkey blood with poliomyelitis virus, have been allowed to feed on fresh monkeys. In one experiment we inoculated a yearling colt intravenously and intracerebrally with a large amount of poliomyelitis virus and exposed this animal at once to some 2000 *Stomoxys*, which were then allowed to bite fresh monkeys. Neither the colt nor the monkeys showed symptoms in any way suggestive of poliomyelitis.

Two experiments were carried out with flies caught in the immedi-

ate vicinity of the residences of poliomyelitis patients in Buffalo, N. Y. These flies were then shipped to the Hygienic Laboratory and there allowed to feed upon fresh monkeys.

Contrary to what might have been expected from the results of our first experiment, we have been unable to transmit the infection thru *Stomoxys* in a single one of our later experiments. Up to this time we have found no satisfactory explanation for this discrepancy in results. The flies used in our later experiments have been generally as numerous and as active and have fed as freely as those used in our first experiment. In some of our later experiments the inoculated monkeys have been exposed as promptly after inoculation, that is, after only two hours; and, so far as we are able to see, all the conditions of our first experiment have been duplicated.

The question has occurred to us whether the season of the year has any peculiar influence upon the transmission of poliomyelitis thru the *Stomoxys*. Our own first experiment, as well as those of Rosenau and Brues, was carried out in the early autumn, during the season when poliomyelitis is commonly quite prevalent in nature. Our later experiments, in the late autumn and winter months, were carried out during a season when this disease is quite rare in nature; but in order to simulate summer conditions a temperature of 75° to 85° F. was maintained in the room where these experiments were carried out. Altho there is no apparent reason why the season alone, regardless of the temperature maintained, should have exerted any special influence upon the outcome of our experiments, it appears to us worth while to repeat the experiments during the summer and autumn months.

In the meantime, it is impossible to estimate accurately the importance which *Stomoxys* may play in the transmission of poliomyelitis. That it is an important natural factor appears to us doubtful, not only because of our own negative results but also because recent experiments have afforded additional evidence of the direct transmissibility of poliomyelitis and because epidemiological studies appear to us to indicate that the disease is probably transmitted largely through passive human virus carriers.

Nevertheless, our negative results need not be taken as conclusive. The demonstration of the infectiousness of the nasal and buccal secretions of poliomyelitis patients was made only after a considerable number of experiments had been performed with entirely negative results. The same is true of several other recently established facts in experimental poliomyelitis. J. F. A. and W. H. F.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE WASHINGTON ACADEMY OF SCIENCES

The 83d meeting of the Washington Academy of Sciences was held at the Cosmos Club, Saturday evening, March 1, 1913. The following were elected resident members of the Academy: BERT S. BUTLER, F. C. CALKINS, WILLIAM MANSFIELD CLARK, RICHARD B. DOLE, CLARENCE N. FENNER, H. L. FERGUSON, ARTHUR W. GRAY, HENRY HINDS, C. W. KANOLT, FRANK LEVERETT, F. L. LEWTON, GERALD L. LOUGHLIN, CURTIS F. MARBUT, HERBERT E. MERWIN, M. J. MUNN, J. B. NORTON W. A. ORTON, N. S. OSBORNE, L. A. ROGERS, WILLIAM H. ROSS, ROBERT B. SOSMAN, J. W. SPENCER, L. W. STEPHENSON, RODNEY H. TRUE, JOSEPH B. UMPLEBY, ROGER CLARK WELLS, FRANK WENNER.

After the election of new members, the Academy, in joint session with the Philosophical Society, listened to an address by the Right Honorable JAMES BRYCE, O. M., Ambassador to the United States, on *The physical aspects of Australia and New Zealand.*

The speaker's theme was a recent trip he had taken thru both these countries, and he made it broad enough to cover the most diverse subjects—the geography, the geology, the ethnology, the fauna, the flora, the history and the political economy of these great countries, all of which he made delightfully interesting by the aid of maps, charts, pictures, and by his own clearness and accuracy of description.

The 84th meeting of the Washington Academy of Sciences was held at the Cosmos Club, Monday evening, March 31, 1913. Dr. EDWARD C. FRANKLIN of the Hygienic Laboratory spoke on *Ammonia, with experiments.*

It was explained that many of the properties, both physical and chemical, of liquid ammonia are similar to those of water; and in particular that just as we have water derived acids, bases, and salts, or a water chemistry, so too there is an ammonia chemistry consisting of an extensive series of ammonia derived acids, bases, and salts. The parallel between the two chemistries, as Dr. Franklin's explanations made clear and his many ingenious experiments demonstrated is complete in every particular.

The 85th meeting of the Washington Academy of Sciences was held on April 23, 1913, at the Cosmos Club. Professor Dr. W. WIEN of the University of Würtzburg spoke on *Recent theories on heat and radiation.* Published in full in this Journal **3**: 273. 1913.

W. J. HUMPHREYS, *Recording Secretary.*

## THE CHEMICAL SOCIETY

### (Local Section of the American Chemical Society)

The 224th meeting was held on March 13, 1913 at the George Washington University Medical School. President Waters in the chair.

Mr. Sverre Gulbrandsen, of the Welsbach Light Company, spoke on *Incandescent gas lighting*. After reviewing the early history of gas lighting by incandescent mantles, the speaker described the discoveries of Auer, and the present process of manufacture of mantles. One of the recent improvements in mantle manufacture consists in the use of squirted fibers of soluble cellulose. The properties of the mantle depend primarily upon those of the original supporting fiber. Mantles from artificial fiber show less shrinkage and hence less loss of luminosity, and also less weakening with age, than those from natural fibers. They are also about three times as strong initially, as the lecturer showed experimentally.

The 225th meeting was held at the Cosmos Club on April 11, 1913.

Prof. Ralph S. Lillie of the University of Pennsylvania spoke on the subject, *Physico-chemical conditions of anesthetic action*. Some conditions that produce effects akin to anesthesia are: lowering of temperature, lack of oxygen, mechanical shock, and exposure to electric current. The effect of a steady small current may be to increase or decrease the irritability of nerve or muscle, depending on the effect of the current upon the potential differences at the cell membranes. The plasmal membrane of cells is a very important factor in their reaction toward substances in solution. These membranes are semipermeable with respect to some solutes, and are freely permeable to others, the latter being usually lipoid-soluble substances. Experiments with electric currents of different frequencies give evidence that the seat of the most constant and characteristic phenomenon of irritability, namely, the electric potential difference, lies in the semipermeable membrane of the cell. Change in irritability is also accompanied by a change in the permeability of the membrane. Anesthetic substances change the susceptibility of a membrane to those changes of permeability which are necessary to stimulation. Experiments by the author on marine organisms whose cells contain a rapidly diffusing pigment show clearly that the anesthetic effect of certain salts is due to their effect on the susceptibility of the cell membrane to permeability increase and not to their effect on the cell contents. The lipoid-soluble anesthetics, such as ethyl ether, all act in the same way as the salts. It appears that the primary process in stimulation is a membrane process, and the effect of anesthesia is upon this primary process. The chemical explanation of this effect is unknown, but may be due to a disturbance of the mutual relations of the colloids of the membrane.

*Discussion.* Wells spoke of the many different causes of electric potentials in liquids, and inquired whether oxidation and reduction potentials might not be operative. Professor Lillie replied that a

number of theories in addition to those he had given had been suggested for these potentials, and the subject is still unsettled. The fact remains that if the semipermeability of the membrane is destroyed, the potential difference is lowered or disappears. To an inquiry by BERG, as to the bearing of certain experiments on the injection of lecithin-saturated ether upon the theory, it was replied that these experiments do not settle the point. GORE inquired as to the effect of calcium salts.

The 226th meeting was held at the Cosmos Club on Friday, May 2, 1913.

Prof. EUGENE C. BINGHAM, of Richmond College, Richmond, Va., spoke on the subject, *Fluidity and its relation to other physical and chemical properties*. Viscosity and fluidity were first defined, and their analogy to electric resistance and conductance brought out. The evidence shows that fluidities and not viscosities are additive. For this reason the relation of fluidity to temperature approaches a straight line. Liquid emulsions and solid suspensions, as well as mixtures of liquids, have been studied by the author. In the case of emulsions, viscosity tends to be additive, as expected. In suspensions, zero fluidity appears at a percentage composition far below that at which the mixture ceases to flow visibly. This composition is believed to represent the dividing line between viscous and plastic flow. In accordance with theory, the zero of fluidity is independent of the liquid and of the temperature. The lecturer then showed many examples of the use of fluidity curves in interpreting the constitution and relations of mixtures of organic liquids, for instance, the indication of a compound between ether and chloroform. The lecture was illustrated by lantern slides and experiments.

*Discussion*. SOSMAN inquired whether a crystalline compound of ether and chloroform is known, corresponding to that shown by the fluidity curve. Professor BINGHAM knew of none. In reply to inquiry by FORD, as to why the curves of zero fluidity were not carried nearer zero, Professor BINGHAM stated that the solid settles out and closes the capillary. BUNZEL mentioned the application of these facts to milk and casein suspensions. The discussion led into the question of the cause of emulsification by dilute alkaline solutions; Professor BINGHAM believed this due in part to the formation of films from the fatty acid or saponifiable oil which might be present. FORD quoted experiments of SPRING in opposition to this view. In reply to a question by BERG, it was stated that the condition of the surface of the solid does not affect the value of fluidity obtained. In support of Professor BINGHAM's view BERG quoted the fact that olive oil, when entirely free from acid, is not emulsified by soda, altho it becomes emulsifiable on standing in air. SOSMAN mentioned the reciprocal relation of density and volume as similar to that of viscosity and fluidity, and spoke of some misconceptions that have arisen because density, instead of volume, was assumed to be the additive property.

C. L. PARSONS gave a brief report on the Milwaukee meeting of the American Chemical Society.

The 227th meeting was held at the Cosmos Club on Thursday, May 8. The following papers were read:

H. C. FULLER, of the Institute of Industrial Research: *The determination of caffein in tea and coffee.* (Read by Mr. WETTENGEL.) The method recommended by the author depends upon the separation of the caffein from the body of the vegetable matter by means of acidulated water, and its extraction from the decoction with chloroform. The caffein is then purified by precipitation with iodin, the iodide is decomposed and the pure alkaloid finally extracted with chloroform.

W. B. HICKS, of the Geological Survey: *A short practical method for the estimation of potassium.* The method consists in the precipitation of potassium by platinum chloride from the acidified solution, washing with alcohol, solution in hot water, and reduction of the chlorplatinate by metallic magnesium to obtain the platinum in a weighable form. The method is applicable in presence of a variety of other salts, and has been used by the author in the analysis of salines.

*Discussion.* In reply to questions by YODER and GRANT, the speaker pointed out that the presence of non-volatile salts would interfere with the determination of the platinum by simple ignition. In reply to a question by SEIDELL, it was shown that sodium chlorplatinate is dissolved out by alcohol, and does not interfere.

R. C. WELLS, of the Geological Survey: *Quantitative relations between oxidizing and reducing solutions.* The use of oxygen and hydrogen electrodes for measuring oxidation and reduction potentials in solutions, such as ferrous and ferric solutions, is rendered possible by the use of platinum. Acidity increases the oxidation potential, while alkalinity increases the reduction potential. The degree of reproducibility of these potentials was discussed. The oxygen and hydrogen potentials in pure water can be calculated, as well as their change with the gas pressure, and the two are found to become equal at 0.68 volt and at $10^{-25}$ atmosphere. This potential marks the true boundary between oxidizing and reducing solutions. Very nearly the same value is obtained by calculation from the known dissociation constant of water at high temperatures.

*Discussion.* BLUM inquired as to contact potentials in the liquid circuit; these are small in comparison with the potentials measured. YODER inquired whether potential measurements could be used to determine acidity in soil solutions; this would be difficult in the presence of oxidizing substances. SULLIVAN suggested an application to biochemical studies. FRANKLIN inquired further as to the ferrous-ferric equilibrium. BLUM stated that the hydrogen electrode has been successfully used for determining acidity in materials such as vinegar and wines.

H. C. GORE, of the Bureau of Chemistry: *The biochemistry of the banana.* Experiments have been made on the ripening of bananas in a respiration calorimeter and in humidors. During ripening the starch decreases, reducing sugars and sucrose increase, and total solids decrease, both in the pulp and peel. There is a considerable increase in the amount of water in the pulp. The respiration rate reaches a maximum

at the time when the starch is decreasing most rapidly. A considerable amount of water is absorbed in the hydrolysis of starch, and water is produced by oxidation; the net result may be either a loss or gain in free water. About 2 per cent of the sugar is oxidized.

*Discussion.* The change in flavor at the end of ripening was discussed by FRANKLIN, GORE and CHESNUT. The point was brought out by SULLIVAN, FRANKLIN and SOSMAN that manganese dioxide, which is present in banana peel, acts like a reducing agent or a catalyzer for reduction. It was stated in reply to questions that bananas are usually ripened off the trees. Means for accelerating or retarding ripening were discussed by McBRIDE, FRANKLIN, HILLEBRAND and GORE. The latter stated that experiments are planned on the effect of carbon dioxide (asphyxiation).

ROBERT B. SOSMAN, *Secretary.*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 269th meeting was held on April 9, 1913, at the Cosmos Club. In the open meeting E. O. ULRICH spoke concerning the age of the Bays sandstone of the Appalachian Valley. New fossils from the type locality prove this exposure at least to be of Black River age.

### REGULAR PROGRAM

*The mud lumps at the mouth of the Mississippi* (illustrated): E. W. SHAW. The "Mud Lumps" are remarkable swellings of dark blue clay in the shallow water at the mouths of the Mississippi. They commonly form islands with a surface extent of an acre or more and a height of 5 or 6 feet. They have always been a serious obstacle to navigation but with the exception of several papers written by Hilgard the published literature concerning them seems meagre when we consider the unusual and important character of the phenomenon. The present paper is only a preliminary notice and a statement of working hypotheses. The principal new hypothesis is that the delta is affected by a bodily seaward flowage and that the mud lumps are incidental to this flowage. This involves the assumption that the outer beds are sandy and comparatively rigid whereas Hilgard believes that just off shore the deposit consists of very watery clay. He sets forth that a crust of sand and silt are built out over this watery clay giving an unstable condition and that wherever the crust is weak the sludge breaks up thru, forming mud lumps. He also thinks that the mud springs which are found on many lumps are vents for the fluid mud underneath. To the present writer these seemed to be incidental to fissuring produced by mud lump upheaval.

*A reconnaissance of the Arctic Slope of Alaska:* E. DE K. LEFFINGWELL. This area is bounded by the Canning River on the west and by the Okpelak River on the east, and extends inland for about 80 miles. Two provinces are recognized, the Arctic Mountains and the Arctic

Slope. The former, composed chiefly of pre-Mesozoic rocks, extend east and west across Arctic Alaska, and are regarded as a continuation of the Rocky Mountain System of the United States and Canada. The Arctic Slope is divided into the Anaktovuk Plateau and the Coastal Plain. The former is a rolling upland forming the northern front of the mountains and is composed chiefly of Mesozoic and Tertiary rocks. The latter is a nearly featureless plain of Pleistocene rocks. The drainage is characterized by a series of closely spaced rivers flowing nearly north from the mountains to the Arctic Ocean.

Schists of probable pre-Cambrian age were deposited and metamorphosed early in the history of the region. The earliest sedimentation of definite age took place in Carboniferous time, when the European section was closely followed. Only 300 feet intervene between the Geschellian and upper Triassic. A series of marine post-Triassic rocks, whose faunas have not yet been studied, probably represent the Jurassic and perhaps extend into the Cretaceous. Evidence from neighboring areas indicates that the Arctic Mountains were deformed in early Tertiary times. Their general accord of summits may indicate base-leveling, but the lack of definite evidence leaves it an open question. The tilted and leveled Pliocene rocks in the Anaktovuk Plateau indicate that this area was uplifted and base-leveled in late Pliocene or early Pleistocene times. The Coastal Plain was uplifted in the Pleistocene, probably before the Wisconsin stage of glaciation. Since then there have been minor oscillations probably less than 25 feet in amount.

*Ores of the Mount Lyell copper district of Tasmania* (illustrated): C. C. Gilbert and J. E. Pogue. Two types of deposits are represented, typified in the two largest mines of the district. The Mount Lyell mine opens up a pyritic mass of immense size, low in copper content but with values in gold and silver. The ore is densely granular pyrite, bearing thruout chalcopyrite in minute stringers and filaments and including localized areas of tetrahedrite and of enargite. Bornite, chalcopyrite, sphalerite, and galena are also present but in subordinate amounts. At the North Mount Lyell mine the ore minerals, in order of importance, are bornite, chalcopyrite, chalcocite, tetrahedrite, and pyrite; these form mineralized zones in the schists and not a great pyrite body as at Mount Lyell. Metallographic study of polished sections indicates that both types of deposits were dominantly formed thru replacement of the minerals of the schists, and that the deposition took place during a distinct mineralizing epoch marked by solutions progressively changing in composition and depositing a series of sulfide minerals in sequential and transitional stages. The order of deposition among the principal minerals is pyrite, chalcopyrite, bornite, chalcocite, corresponding to a decreasing iron and increasing copper content. Enargite and tetrahedrite probably mark a late stage in the mineralizing epoch; with these chalcopyrite of a second generation is associated. The sections give no conclusive evidence of secondary sulfide enrichment. The ores studied are the property of the U. S. National Museum.

Ralph W. Richards, *Secretary.*

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GEOPHYSICS.—*Volcanic dust as a factor in the production of climatic changes.*[1] W. J. Humphreys, Weather Bureau. To be published as a Bulletin of the Weather Bureau.

Geological investigations have given us a great deal of information in regard to the climates of the past, and the following tentative conclusions appear to be well established: (*a*) The climatic changes were several, probably many. (*b*) They were simultaneous over the entire earth, and in the same sense. That is, colder everywhere at the same time (climatically speaking) or warmer everywhere. (*c*) They were of unequal intensity. (*d*) They probably were of irregular occurrence, and of unequal duration. (*e*) They, at least one or more, progressed with secondary variations of intensity, or with advances and retreats of the glacial edge. (*f*) They have occurred from very early, probably from the earliest, geological ages down to the present, and presumably will continue irregularly to recur for many ages yet to come.

Many efforts have been made to find a probable and at the same time an adequate physical basis for, or cause of the climatic changes that are known to have occurred; but, one after another, nearly all have been definitely and finally abandoned, either because of inconsistency with known physical laws or because they proved inadequate to meet the conditions imposed by geological investigations.

[1] Presented in substance before the Astronomical and Astrophysical Society of America, at Cleveland, O., January 1, 1913.

Doubtless there have been several contributing causes of climatic change, but it is the specific purpose of this paper to discuss only one of these,—a cause that during historic times has often been fitfully operative, and concerning which we have much definite information.

The cause or factor in question is the presence of *volcanic dust in the upper atmosphere.*

Volcanic dust has often been mentioned as a possible cause of cold seasons. Thus in May, 1784, Benjamin Franklin (and he may not have been the first) wrote as follows:

During several of the summer months of the year 1783, when the effects of the sun's rays to heat the earth in these northern regions should have been the greatest, there existed a constant fog over all Europe, and great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect towards dissipating it, as they easily do a moist fog, arising from water. They were indeed rendered so faint in passing through it, that, when collected in the focus of a burning-glass, they would scarcely kindle brown paper. Of course their summer effect in heating the earth was exceedingly diminished.

Hence the surface was early frozen.

Hence the first snows remained on it unmelted, and received continual additions.

Hence perhaps the winter of 1783–4 was more severe than any that happened for many years.

The cause of this universal fog is not yet ascertained. Whether it was adventitious to this earth, and merely a smoke proceeding from the consumption by fire of some of those great burning balls or globes which we happen to meet with in our course round the sun, and which are sometimes seen to kindle and be destroyed in passing our atmosphere and whose smoke might be attracted and retained by our earth; or whether it was the vast quantity of smoke, long continuing to issue during the summer from Hecla, in Iceland, and that other volcano which arose out of the sea near that island, which smoke might be spread by various winds over the northern part of the world is yet uncertain.

It seems, however, worth the inquiry, whether other hard winters, recorded in history, were preceded by similar permanent and widely extended summer fogs. Because, if found to be so, men might from such fogs conjecture the probability of a succeeding hard winter, and of the damage to be expected by the breaking up of frozen rivers in the Spring; and take such measures as are possible and practicable, to secure themselves and effects from the mischiefs that attend the last.[2]

[2] See Sparks, "Life of Benjamin Franklin," **6**: 455–457. (Cited in Proceedings of the Amer. Phil. Soc., **45**: 127. 1906.)

The idea then that volcanic dust may be an important factor in the production of climatic changes is not new, but hitherto the idea has not been supported either by a clear explanation of the process by which such dust can lower average temperatures or by a discussion of all the available observational data. In fact the rational or theoretical discussion has not long been possible since, in almost every particular, it depends upon the results of recent investigations.

We shall now briefly consider, under separate heads, the several points essential to an understanding of how volcanic dust may influence, and of the extent to which it actually has influenced, our average temperatures—by what process it may modify and to what extent it actually has modified our climates.

*Atmospheric regions.* At an elevation that in middle latitudes averages about 11 kilometers the temperature of the atmosphere becomes substantially constant, or, in general, ceases appreciably to decrease with increase of elevation, this is, therefore, the upper limit of distinct vertical convection and of cloud formation. Hence, while volcanic or other dust in the lower or cloud region of the atmosphere is quickly washed out by snow or rain, that which by any process happens to get into the upper or isothermal region must continue to drift there until gravity can bring it down to the level of passing storms. In other words, while the lower atmosphere is quickly cleared of any given supply of dust, the isothermal region retains such dust as it may have for a time that depends upon the size and density of the individual dust particles themselves, or upon the rate of fall.

*Size of volcanic dust particles.* From the angular dimensions of a reddish brown corona, known as Bishop's ring, seen around the sun after the eruptions of Krakatoa, Pelé and certain other volcanoes, it has been calculated, by the aid of the laws of diffraction, that the average diameter of the particles to which this ring was due, assuming them spherical, was about 1.85 microns. Hence, with this information, it becomes possible to calculate the time of fall of volcanic dust.

*Time of fall.* By using the excellent measurements recently made by McKeehan[3] on the terminal velocity of falling globules,

[3] Phys. Rev., **33**: 153. 1911.

it is easy to show that spherical particles of volcanic dust of the size above determined would require more than a year to fall from only the maximum height already reached by sounding balloons down to the upper cloud limit. But as most volcanic dust does not consist of solid spheres, but rather of flakes and rods, and again, as much of it is finer than the size assumed, it follows that the time of fall may, in rare cases, be as much as two to four years, or possibly even longer. Obviously then volcanic dust once in the upper atmosphere must remain in it for many months and be drifted out, from whatever origin, into a thin veil covering perhaps the entire earth. Hence to find its effect on the temperature of the lower atmosphere it is necessary to determine its action on radiation, both terrestrial and solar.

*Comparative action of volcanic dust on terrestrial and on solar radiations.* Since those volcanic dust particles that remain long suspended in the atmosphere are large in comparison to the cube of the wave-length of solar radiation, at the region of maximum intensity, and small in comparison to the cube of the wave-length of terrestrial radiation, also at the region of maximum intensity, it is easy, by the use of equations developed by Rayleigh,[4] to compare the action of the dust on the two kinds of radiation.

This calculation shows that volcanic dust particles, of the size indicated by Bishop's ring, is roughly 30 fold more effective in shutting solar radiation out than it is in holding terrestrial radiation in. Therefore a veil of volcanic dust must produce an inverse green-house effect, and, if long continued, should perceptibly lower our average temperature. Let us see then what observational evidence we have on the effect of volcanic dust on insolation intensity and average temperatures.

*Pyrheliometric records.* This subject has been carefully studied by Dr. Kimball[5] of the U. S. Weather Bureau, who finds that there was a marked decrease in the insolation intensity from the latter part of 1883 (the year this kind of observation was begun) to and including 1886, from 1888 to 1892, and during 1903. There has also been a similar decrease since about the

[4] Phil. Mag., **47**: 375. 1899.
[5] Bull. Mt. Weather Obsy., **3**: 69. 1910.

DISCREPANCIES BETWEEN AVERAGE TEMPERATURES AND SUN-SPOT NUMBERS

| DATE | NATURE OF DISCREPANCY | PROBABLE CAUSE |
|---|---|---|
| 1755–56 | Cold | Kōtlugia, Iceland, 1755. |
| 1766–67 | Cold | Hecla, Iceland, 1766.<br>Mayon, Luzon, 1766. |
| 1778–89 | Warm | Maximum number (annual) of sun-spots ever e-corded and unusually short spot period. Can it be that the solar constant actually was distinctly greater than usual at this time? |
| 1784–85–86 | Cold | ASAMA,[1] Japan, 1783. The most frightful eruption on record.<br>Skaptar Jökull, Iceland, 1783.<br>Vesuvius, Italy, 1785. |
| 1799 | Cold | Fuego (?), Guatemala. (Uncertain.) |
| 1809 | Cold | St. George (?), Azores, 1808. (Uncertain.) Etna(?), Sicily, 1809. (Uncertain.) |
| 1812–13–14–15–16 | Cold | Soufrière, St. Vincent, 1812.<br>Mayon, Luzon, 1814.<br>TOMBORO, Sumbawa, 1815, very great. |
| 1831–32 | Cold | Graham's Island, 1831.<br>Babujan Islands, 1831.<br>Pichincha, Ecuador, 1831. |
| 1856–57 | Cold | Cotopaxi (?), and others, 1855–56. (Uncertain.) |
| 1872–73 | Cold | Vesuvius, Italy, 1872.<br>Merapi, Java, 1872. |
| 1875–76 | Cold | Vatna Jōkull, Iceland, 1875. |
| 1884–85–86 | Cold | KRAKATOA, Straits of Sunda, 1883, greatest since 1783.<br>Saint Augustin, Alaska, 1883.<br>Tarawera, New Zealand, 1886. |
| 1890–91–92 | Cold | Bogoslof, Aleutian Islands, 1890.<br>Awoe, Great Sangir, 1892. |
| 1902–03–04 | Cold | Pelé, Martinique, 1902.<br>Santa Maria, Guatemala, 1902.<br>Colima, Mexico, 1903. |
| 1912–13 | Cold | Katmai, Alaska, 1912. |

[1] Capitals indicate exceptional violence.

middle of 1912. Now all these decreases of insolation intensity, amounting at times to 20 per cent of the average intensity, followed violent volcanic eruptions that filled the isothermal region with a great quantity of dust.

*Surface temperatures.* It has been known for a long time that the number of sun-spots and the average temperature of the earth are roughly related in the sense that the greater the number of spots the lower the temperature, and the smaller the number of spots the higher the temperature. But this relation has many marked exceptions, every one of which, or at any rate all the more important ones, occurred immediately after violent volcanic explosions and presumably therefore were caused by volcanic dust.

The list on page 369 gives the more important of these discrepancies, since the beginning of sun-spot records to the present, and their probable causes.

From the above it appears quite certain that volcanic dust can lower the average temperature of the earth by an amount that depends upon the quantity and duration of the dust, and that it repeatedly has lowered it certainly from 1°F. to 2°F. for periods of from a few months to fully three years. Hence it certainly has been a factor, in determining our past climates, and presumably may often be a factor in the production of our future climates. Nor does it require any great volume of dust to produce a marked effect. Thus it can be shown by a simple calculation that less than the one thousandth part of a cubic mile of rock spread uniformly thru the upper atmosphere as volcanic dust would everywhere decrease the average intensity of insolation received at the surface of the earth by at least 20 per cent and therefore would, presumably, if long continued, decrease our average temperatures by several degrees.

## CONCLUSION

It has been shown in the above, among other things, that volcanic dust in the high atmosphere decreases the intensity of solar radiation in the lower atmosphere, and therefore the average temperature of the earth, substantially as theory indicates

*a priori* that it should; and this effect has been clearly traced back to 1750, or to the time of the earliest reliable records. Hence it is safe to say that such a relation between volcanic dust in the upper atmosphere and average temperatures of the lower atmosphere has always obtained, and therefore that volcanic dust must have been a factor, possibly a very important one, in the production of many, perhaps all, past climatic changes, and that thru it, at least in part, the world is yet to know many another climatic change in an irregular but well-nigh endless series—usually slight tho always important, but occasionally it may be, as in the past, both profound and disastrous.

PHYSICS.—*Melting points of the refractory elements. I. Elements of atomic weight from 48 to 59.* G. K. BURGESS and R. G. WALTENBERG, Bureau of Standards. To appear in The Bulletin of the Bureau of Standards.

The elements included in this list are the iron group: nickel, cobalt, iron, manganese and chromium, and also vanadium and titanium. In subsequent papers results will be given on other refractory elements now being studied, and it is hoped eventually to include all the available refractory elements in this series of melting point determinations. The method mainly used is that of the micropyrometer[1] which, with substances that melt sharply as nickel, cobalt and iron, permits working to a precision of 1 or 2 degrees with a few thousandths of a milligram of the material.

An estimation of the melting points of the iron group elements[2] was made some years ago by a similar but less sensitive method at a time when none of these melting points was well known. The object of these earlier measurements was primarily to demonstrate the convenience and reliability of the method especially for those elements which can be obtained pure only in minute quantities. It is believed that the present series of determinations, with the improved apparatus, will contribute to a more exact

[1] A micropyrometer, by G. K. Burgess, Jl. Washington Academy of Sciences, **3**: 7. 1913. Phys. Zs., **14**: 158. 1913. Bull. Bureau of Standards, **9**: 475. 1913.

[2] Melting points of the iron group elements by a new radiation method, by G. K. Burgess. Bull. Bureau of Standards, **3**: 345. 1907.

knowledge of these melting points. The melts were made for the most part in pure hydrogen, and except for titanium, were taken on platinum strips 6 to 8 cm. long, 4 mm. wide, and 0.01 or 0.02 mm. thick. Manganese was also melted on nickel strips and titanium was melted on iridium strips.

*Calibration with nickel and palladium.* For melts on platinum the pyrometer was calibrated in terms of the melting points of nickel and palladium. The melting of these metals is extremely sharp on platinum and they appear to show no alloying until they melt. It is assumed that they melt on platinum at the same temperatures as in crucibles; this we have found to be the case for nickel, palladium, platinum, and iron. Numerous observations were made with various metals upon the possible effects on the melting point determinations of alloying with the platinum strip. We are convinced, that except possibly in some cases which we shall not consider here in which there may be a chemical reaction among the materials in the furnace, as for example when silicon, platinum and hydrogen are together, there is no significant alloying effect with the apparatus and materials as we use them.

The melting points of both nickel and palladium may be considered as well established by several series of measurements.[3] We have made an independent optical determination of the nickel melting point in hydrogen with an Arsem furnace.[4] The nickel was melted in a magnesia crucible contained within an out-glazed, closed-end porcelain or kaolin tube. Temperatures were measured with a Holborn-Kurlbaum form of Morse pyrometer which had been calibrated by Dr. Kanolt at the melting points of antimony (630°), $Ag_3Cu_2$ (779°), silver (960°.5), copper (1083°), and diopside (1391°). Five observations by Dr. Kanolt on the melting point of platinum with this pyrometer gave 1755° ± 5 in an iridium furnace, or in exact agreement with the generally accepted value.[3]

For nickel, four observations gave us 1449°, 1450°, 1449°, 1449°

[3] See Day and Sosman, Carnegie Institution of Washington, Pub. 157, 1911. Waidner and Burgess, Bull. Bureau of Standards, **3**: 163. 1907.

[4] Jl. Am. Chem. Soc., **28**: 921. 1906.

in the Arsem furnace, by the method of optical heating and cooling curves,[5] values which are close to Day and Sosman's value, 1452°. Four observations of the melting point of nickel on iridium with the micropyrometer gave us 1452°.

With the long filament pyrometer lamps used, the equation[6] $\log c = a + b \log T$ (in which $c$ = current and $T$ = absolute temperature and $b$ is very nearly unity) is sufficient for very considerable temperature ranges, and permits a calibration in terms of two temperatures only, i.e., nickel and palladium. Applying this equation by extrapolation to the determination of the platinum melting point by observing the melting of platinum strips mounted as usual for taking metal melts, we obtained 1755° ± 5 from six observations. The values found for diopside (1391°) and anorthite (1549°) by Day and Sosman were also exactly reproduced by us with the micropyrometer.

The metals actually used for calibration in hydrogen were "Kahlbaum" electrolytic nickel ($MP$ = 1452°) and pure Heraeus palladium ($MP$ = 1549°), both of the same grade as used by Day and Sosman.[7] A sample of their palladium gave exactly the same melting point as ours. In controlling the constancy of the pyrometer lamps and studying the reproducibility of the melts some 35 observations were taken of nickel and 20 of palladium. The various metals were not studied in regular order but were mixed as indiscriminately as possible, with observations on the standard points, nickel and palladium.

*Iron.* Pure electrolytic iron from three sources and as many different methods of preparation was used, namely, from Prof. C. F. Burgess (99.97 per cent Fe) from Langheim-Pfanhauser Werke A. G. (99.98 per cent Fe) and from a sample (99.99 per cent Fe) prepared by Mr. J. R. Cain of this Bureau. "Kahlbaum" iron in powdered form and iron reduced on the platinum strip in hydrogen from Kahlbaum iron oxide were also used.

[5] C. W. Kanolt, Tech. Paper No. 10, Bureau of Standards, 1912.

[6] Pirani, Verh. Phys. Ges., **12**: 323. 1910.

[7] Day, Sosman and Allen, l. c. The analysis by Dr. Allen of these products gave the nickel as 99.835 pure and the palladium 99.975.

TABLE I

MELTING POINT OF IRON IN HYDROGEN BY MICROPYROMETER

| | |
|---|---|
| Electrolytic, C. F. Burgess | 1538°, 1537°, 1530°, 1534°, 1530°, 1532° |
| Mean | 1533° |
| Electrolytic, Langheim-Pfanhauser | 1524°, 1532°, 1534°, 1534°, 1535° |
| Mean | 1532° |
| Electrolytic, Cain | 1533° |
| Powder, "Kahlbaum" | 1534° |
| From Oxide, "Kahlbaum" | 1532° |

The mean value is 1533° ± 1°. This is somewhat higher than all other recent determinations, which range from 1502° to 1532°. In the Arsem furnace, we obtained *in vacuo* 1531°, 1529°, 1531°, 1527°, and in hydrogen 1523° and 1527°.

*Cobalt.* The cobalt used was cobalt "Kahlbaum" in the form of powder, Kahlbaum's Würfeln, cobalt reduced in hydrogen on the platinum strip from "Kahlbaum" cobalt oxide, and a sample kindly furnished by Messrs. Day and Sosman, cut from material which had been used for their determinations and which was originally powdered cobalt "Kahlbaum,"[8] shown by Dr. E. T. Allen to be 99.951 per cent cobalt. The mean is 1477° ± 2.

TABLE II

MELTING POINT OF COBALT BY MICROPYROMETER

| | |
|---|---|
| "Kahlbaum," powder and Würfel together; | 1478°, 1479°, 1482°, 1476°, 1475°, 1476°, 1478° |
| Mean | 1478° |
| Co from the oxide "Kahlbaum" | 1475°, 1478° |
| Day and Sosman's sample | 1474°, 1478°, 1478° |

Three observations taken in the Arsem furnace each gave for the melting point of cobalt 1478°. Finally two melts of cobalt on iridium gave with the micropyrometer 1477° and 1478°. The value of the cobalt point which Day and Sosman found is 1490° in a nitrogen atmosphere.

*Chromium.* Strictly pure chromium was not available, and it is difficult to locate exactly the melting points of an impure viscous substance. Observations were taken on two samples from

[8] Day, Sosman and Allen, l. c.

Kahlbaum and on one from Dr. H. Goldschmidt, all of a purity probably not greater than 98 per cent.

TABLE III

MELTING POINT OF (98 per cent?) CHROMIUM BY MICROPYROMETER

| | |
|---|---|
| Kahlbaum I | 1527° |
| Kahlbaum II | 1536°, 1513°, 1513° |
| Goldschmidt | 1514°, 1524° |

As the best representative value we may take 1520°. The melting point of pure chromium, however, may well be above that of iron, as may be shown by a consideration of the well known formula for lowering the freezing point by metallic impurities. On the other hand, the value 1520° may be more nearly correct if the oxides present do not lower but raise the chromium melting point as was found in the case of vanadium by Ruff and Martin.[9] If chromium is melted, for example, in a slightly oxidizing atmosphere or in impure hydrogen, an apparent melting point above that of platinum may be obtained.

*Manganese.* We have not been able to obtain pure manganese, and the impure samples from Kahlbaum and from Goldschmidt are even more sluggish than chromium. The Goldschmidt manganese was from a sample of about 97.5 per cent pure. Melts were taken both on platinum and on nickel strips with the micropyrometer using gold (1063°) and palladium as calibration points. Those on nickel were less satisfactory, due apparently to evaporation of nickel.

TABLE IV

MELTING POINT OF (97.51) MANGANESE BY MICROPYROMETER

| | |
|---|---|
| Kahlbaum | on Pt., 1242°; on Ni 1221° |
| Goldschmidt | on Pt., 1261°, 1264°, 1279°; on Ni 1254° |

The mean is 1254°, which is probably lower than the melting point of strictly pure manganese by 20°.

*Vanadium.* Dr. v. Wartenberg of Berlin kindly sent us some 97 per cent vanadium prepared by him from the suboxide by

[9] Ruff and Martin, Über reines Vanadin. Zs. Angew. Chem., 25: 49. 1912.

the alumino-thermic method with calcium; it contains traces of Ca, Al and Fe. Professor Wedekind of Strassburg also furnished us with a sample of his 97 to 98 per cent vanadium. We have also examined two samples purchased from Kahlbaum at different dates. None of the samples melts sharply, the substance being viscous; all samples show evidences of incipient melting many degrees below the temperature at which the melting is complete.

With the Kahlbaum samples, evidences of melting were apparent as low as 1500°; melting was complete at about 1720°, the samples showing evidences of non-homogeneity of composition.

With Dr. v. Wartenberg's and Professor Wedekind's vanadium the following results were obtained:

TABLE V

Melting Point of 97 per cent Vanadium by Micropyrometer

97 to 98 per cent V from Wedekind.....................1700°, 1757°, 1773°, 1717°
97 per cent V from v. Wartenberg; 1680°, 1691°, 1691° (pieces of about 0.001 mg.), 1685°, 1699°, 1705° (medium sized pieces), 1725° (largest pieces).

Evidences of incipient melting were apparent at about 1650° with these materials. Other determinations of the vanadium melting point range from 1680° to 1750°. We would place the vanadium melting point at about 1720°, both from a consideration of our own and of other determinations.

*Titanium.* Prof. M. M. A. Hunter, of Rensselaer Polytechnic Institute kindly placed at our disposal a sample of pure titanium, which he had prepared from material furnished by the Titanium, Alloy Manufacturing Company of Niagara Falls. This titanium, analyzed by Professor Hunter, contains only a trace of iron and no other detectable impurity. Professor Wedekind likewise kindly sent us two samples prepared by him of 94 to 95 per cent purity and one by Dr. v. Wartenberg. The colloid titanium of Wedekind melted at 1508° to 1451°, and his powdered titanium at 1452°. We also took observations on two samples from Kahlbaum, which were evidently quite impure, showing evidences of an extended melting range. For the Kahlbaum samples the following melting points were obtained: 1664°, 1724°, 1677°, 1737°, 1641°. The titanium of Hunter and of v. Wartenberg showed

no signs of melting on platinum; their melting points were taken on iridium strips.

TABLE VI

MELTING POINT OF TITANIUM BY MICROPYROMETER

| | |
|---|---|
| Ti From Professor Hunter | 1790°, 1785°, 1785° |
| Mean | 1788° |
| Ti From Dr. v. Wartenberg | 1778°, 1807,° 1815° |
| Mean | 1800° |

These melting points are fairly sharp, and the location of the temperature was made by calibrating the micropyrometer for the iridium strip by taking observations on it of the melting of palladium (1549°), and of platinum (1755°).

*Summary.* We have shown that the micropyrometer may be made an instrument of precision for the determination of the melting points of refractory metals and salts; that in the case of the metals examined, the effect of alloying of microscopic particles on platinum and iridium is inconsequential until after melting which we have shown for nickel, cobalt and iron to occur at the

TABLE VII

MELTING POINTS OF ELEMENTS OF ATOMIC WEIGHT 48 TO 59

| METAL | MELTING POINT WITH MICROPYROMETER | PURITY | PROBABLE MELTING POINT OF PURE ELEMENT |
|---|---|---|---|
| | | *per cent* | |
| Nickel | 1452°* <br> 1449† | 99.83$_6$ | 1452° ± 3 |
| Cobalt | 1477 ± 2 <br> 1478 ± 1‡ | 99.95$_1$ | 1478° ± 5 |
| Iron | 1533 ± 1§ <br> 1528 † | 99.98 ± 01 | 1530° ± 5 |
| Manganese | 1255 | 97 to 98 | 1260° ± 20 |
| Chromium | 1520 | 98 to 99 | 1520° to > Fe |
| Vanadium | 1720 | 97 to 98 | 1720 ± 20 |
| Titanium | 1794 ± 12 | 99.9+ | 1795 ± 15 |

* Assumed value on platinum strip; also observed value on iridium strip.

† Crucible melts in electric furnace.

‡ Crucible melts in electric furnace; also on iridium strip with micropyrometer.

§ Five samples all agreeing to within 3°.

same temperature for minute particles on the strips as for considerable quantities in crucibles of magnesia.

Assuming the melting points of nickel to be 1452°, palladium 1549° and platinum 1755°, and the calibration curves of the pyrometer lamps of the form $\log c = a + b \log T$, for the range here studied, we have determined the melting points of Fe, Co, Cr, Mn, V and Ti with the micropyrometer and of Ni, Co and Fe in quantity in the electric furnace, all melts having been taken in pure hydrogen and Fe also *in vacuo*. For Cr, Mn and V, strictly pure materials were not available, and we can but estimate the melting points of the pure elements.

In the complete paper, the method is discussed more in detail and photomicrographs are given showing characteristics of the various melts.

## PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

### THE BOTANICAL SOCIETY OF WASHINGTON

The 89th regular meeting of the Botanical Society of Washington was held on May 6, 1913, at the Cosmos Club with twenty-four members and two guests present.

The following papers were presented:

*The effect of the recent freeze in California* (illustrated): Dr. DAVID GRIFFITHS. Dr. Griffiths discussed the effect of the January freeze on vegetation of the southwest, with special reference to California. The main regions where tropical and subtropical things are being grown were visited. He showed 40 lantern slides made from negatives taken in February and March, showing injuries to citrus fruits, avocados, cherimoyas, mangoes, carobs, acacias, olives, eucalyptus, etc.

While the temperatures were unusually low, there are indications that they have been lower in the remote past. That such cold spells of weather are very infrequent is proved by the fact that such natives as Rhus laurina, eriogonums in California, and the giant Cereus, scholla, Celtis, Olneya, etc., in southern Arizona are severely injured. Many introduced trees which had attained a diameter of 3 feet were killed outright. Injuries were very severe thruout all of the citrus regions, but even where the temperatures went to 10–17° Fahr. in general thruout a region, an occasional orchard situated upon an abrupt elevation above the general plain escaped with even unfrozen fruit. Because of differences in elevation, air-drainage and exposures, conditions are exceedingly varied and present some of the most important problems in connection with the relation of climatic conditions to crop development. At no time in the present generation has there been such an opportunity to determine the adaptability of the scores of introduced plants of the Pacific Coast region. Thru some of the various agencies operating in agricultural lines a careful survey should be made the present season to systematize and place on record the results of a condition which, altho of infrequent occurrence, is nevertheless of the utmost scientific and economic import.

*The method of types applied to the nickernut:* Mr. H. C. SKEELS. Mr. Skeels called attention to the last sentence of division (e) under Canon 15 of the American Code of Botanical Nomenclature, which reads as

follows: "The genera of Linnaeus' Species Plantarum (1753) are to be typified thru the citations given in his Genera Plantarum (1754)." Under this clause the following genera were mentioned:

| GENUS | TYPE SPECIES | NOW REFERRED TO |
|---|---|---|
| Alpinia | *A. racemosa* | Renealmia |
| Cerbera | *C. ahouaj* | Thevetia |
| Crataegus | *C. aria* | Sorbus |
| Cucurbita | *C. lagenaria* | Lagenaria |
| Glycine | *G. apios* | Apios |
| Hibiscus | *H. malvaviscus* | Malvaviscus |
| Jatropha | *J. manihot* | Manihot |
| Medicago | *M. radiata* | Trigonella |

Applying the method of types to the nickernut, Mr. Skeels called attention to Mr. Trimen's identification of the Flora Zeylanica specimens which are published in volume 24 of The Journal of the Linnean Society, Botany. On the basis of these identifications, Mr. Skeele concluded as follows:

"In conclusion, going back to our three original species, the 'Catti kitsjil' of the East Indies, the *Caesalpinia nuga* (L.) Aiton of the floras, under the method of types of the American Code, becomes *Caesalpinia crista* L., the type being Fl. Zeyl. 157. The common grey-seeded nickernut generally known as *Caesalpinia* or *Guilandina bonducella*, becomes *Guilandina bonduc* L., the type being Fl. Zeyl. 156. And the yellow-seeded, large-leafletted nickernut, generally known as *Guillandina bonduc* becomes *Guilandina major* (DC.) Small, being based thru De Candolle, on *Guilandina bonduc* L. Species Plantarum, ed. 2."

*What would be the effect of the Arctic night on tropical or subtropical vegetation?* Dr. F. H. Knowlton. Dr. Knowlton called attention to the ancient floras of the North Polar region. Many of the fossil plants found there are of a tropical or subtropical character. No satisfactory explanation of the relation of such plants to the conditions of light and darkness supposed to have prevailed has been found. Dr. Knowlton asked for suggestions from the members of the Society and a brief discussion followed.

C. L. Shear, *Corresponding Secretary.*

THE PROCEEDINGS

OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str., Berlin.

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# JOURNAL

OF THE

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Vol. III | AUGUST 19, 1913 | No. 14


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METEOROLOGY.—*Evaporation in the great plains and intermountain districts as influenced by the haze of 1912.* LYMAN J. BRIGGS and J. O. BELZ, Bureau of Plant Industry.

It has recently been shown by Abbot and Fowle[1] and by Kimball,[2] that the haze of 1912, presumably due to the eruption of Mt. Katmai on June 6 and 7, 1912, gave rise to a marked diminution in the intensity of the solar radiation at the earth's surface. Abbot and Fowle found that the total direct radiation of the sun was reduced about 20 per cent at Bassour, Algeria, and also at Mt. Wilson, California, when the effect reached its maximum in August. Kimball reports an average reduction of 17 per cent in the intensity of the solar radiation received at Mt. Weather, Va., during the last half of 1912, while at Madison, Wis., an average reduction of 14 per cent was observed for the same period.

During the past five years the writers have been engaged in a series of evaporation measurements[3] in the great plains and intermountain districts, and it has seemed desirable to determine to what extent the reduction in the solar intensity during 1912 affected the evaporation. In making such a comparison, it must of course be recognized that evaporation is profoundly in-

[1] Smithsonian Miscellaneous Collections, **60**: 29. 1913.

[2] This Journal, **3**: 269. 1913. Also, Bull. Mt. Weather Observatory, **5**: 295. 1913.

[3] In coöperation with the Office of Dry Land Agriculture, and the Office of Western Irrigation Agriculture, of the Bureau of Plant Industry.

fluenced by a number of other factors, such as temperature, cloudiness, humidity, and wind velocity. In any comparison of this kind one would, therefore, expect to encounter anomalies in the records from an individual station resulting from these disturbing factors (see Table III).

The evaporation records are based upon daily measurements of the change in elevation of a free water surface, after correcting for precipitation. The evaporation tanks are either 6 or 8

TABLE I

NORMAL EVAPORATION AT STATIONS IN THE GREAT PLAINS AND INTERMOUNTAIN DISTRICTS

| STATIONS | NO. OF YEARS OBS. | APRIL | MAY | JUNE 1-15 | JUNE 16-30 | JULY | AUGUST | SEPT. | TOTAL Apr. 1 to Oct. 1 |
|---|---|---|---|---|---|---|---|---|---|
| | | *inches* | *inches* | *inches* | *inches* | *inches* | *inches* | *inches* | *inches* |
| Amarillo, Tex........ | 5 | 7.55 | 9.09 | 5.22 | 5.54 | 9.68 | 9.06 | 8.00 | 54.14 |
| Dalhart, Tex......... | 4 | 7.89 | 9.73 | 5.70 | 6.25 | 10.56 | 10.04 | 8.26 | 58.43 |
| Garden City, Kans... | 4 | 7.61 | 8.76 | 4.63 | 5.51 | 10.00 | 9.35 | 7.69 | 53.55 |
| Hays, Kans.......... | 5 | 6.85 | 7.26 | 4.24 | 4.61 | 9.09 | 8.82 | 6.96 | 47.83 |
| Akron, Col........... | 4 | 5.43 | 6.91 | 4.10 | 4.43 | 9.36 | 8.61 | 6.85 | 45.69 |
| North Platte, Neb.... | 5 | 6.05 | 6.75 | 3.72 | 4.79 | 8.50 | 7.74 | 6.44 | 43.99 |
| Newell, S. Dak....... | 4 | 4.81 | 6.49 | 3.44 | 4.53 | 9.23 | 7.53 | 5.54 | 41.57 |
| Edgeley, N. Dak..... | 5 | 3.89 | 4.87 | 2.24 | 3.42 | 6.91 | 5.88 | 4.31 | 31.52 |
| Dickinson, N. Dak... | 5 | 4.08 | 5.03 | 2.55 | 3.65 | 7.34 | 6.31 | 4.28 | 33.24 |
| Williston, N. Dak.... | 3 | 4.72 | 6.11 | 2.79 | 4.04 | 7.92 | 6.24 | 4.11 | 35.93 |
| Judith Basin, Mont... | 3 | 4.10 | 5.40 | 2.86 | 3.25 | 7.61 | 6.94 | 4.86 | 35.02 |
| Nephi, Utah......... | 4 | 4.80 | 7.21 | 4.25 | 4.82 | 9.67 | 9.23 | 6.13 | 46.11 |
| San Antonio, Tex..... | 5 | 5.93 | 6.57 | 4.44 | 4.83 | 9.61 | 9.55 | 7.24 | 48.17 |
| Fallon, Nev.......... | 4 | 6.20 | 8.34 | 4.91 | 4.99 | 11.05 | 10.05 | 6.14 | 51.68 |
| Yuma, Ariz.......... | 3 | 8.34 | 10.92 | 5.92 | 5.59 | 11.33 | 11.10 | 8.19 | 61.39 |
| $\Sigma n$.................. | | 88.25 | 109.44 | 61.01 | 70.25 | 137.86 | 126.45 | 95.00 | |

feet in diameter, and 2 feet deep, and are sunk in level ground in a freely exposed space to within 4 inches of the top, the water level being maintained at approximately 4 inches below the top of the tank.

At most of the evaporation stations, "normals" based upon at least four years records, exclusive of those of 1912, are now available. The monthly normal evaporation, from April to September inclusive, for 15 stations located in the great plains and in-

termountain districts, is given in Table I. Since the eruption of Mt. Katmai occurred early in June, the records for this month are divided into two parts. At the foot of the table is given the sum of the combined evaporation occurring at the 15 stations for each month, designated as $\Sigma n$. In Table II is given the evaporation for the corresponding periods during the summer of 1912, the combined evaporation for all of the stations during

TABLE II

EVAPORATION IN 1912 AT STATIONS IN THE GREAT PLAINS AND INTERMOUNTAIN DISTRICTS

| STATIONS | APRIL | MAY | JUNE 1-15 | JUNE 16-30 | JULY | AUGUST | SEPT. | TOTAL Apr. 1 to Oct. 1 |
|---|---|---|---|---|---|---|---|---|
| | *inches* | *inches* | *inches* | *inches* | *inches* | *inches* | *inches* | *inches* |
| Amarillo | 7.05 | 9.90 | 4.95 | 4.04 | 10.95 | 9.49 | 6.49 | 52.87 |
| Dalhart | 8.21 | 10.24 | 4.64 | 3.84 | 11.10 | 9.13 | 6.75 | 53.91 |
| Garden City | 6.86 | 10.82 | 4.77 | 3.81 | 10.64 | 9.15 | 7.09 | 53.14 |
| Hays | 6.08 | 8.28 | 3.13 | 3.29 | 9.99 | 9.18 | 7.02 | 46.97 |
| Akron | 4.68 | 7.10 | 2.90 | 3.85 | 7.62 | 7.05 | 4.65 | 37.85 |
| North Platte | 4.84 | 7.54 | 2.80 | 4.80 | 8.97 | 7.46 | 5.29 | 41.70 |
| Newell | 4.85 | 6.42 | 3.65 | 4.53 | 7.98 | 6.60 | 3.71 | 37.74 |
| Edgeley | 3.69 | 4.60 | 2.33 | 2.67 | 5.69 | 4.24 | 2.74 | 25.96 |
| Dickinson | 3.65 | 4.67 | 2.26 | 3.26 | 6.02 | 5.92 | 3.21 | 28.98 |
| Williston | 3.88 | 4.78 | 3.81 | 3.29 | 5.98 | 4.99 | 2.98 | 29.71 |
| Judith Basin | 2.62 | 4.14 | 2.74 | 3.66 | 5.97 | 6.24 | 3.42 | 28.79 |
| Nephi | 3.54 | 6.30 | 4.20 | 5.08 | 9.24 | 8.89 | 6.16 | 43.41 |
| San Antonio | 4.08 | 7.61 | 3.56 | 3.50 | 10.59 | 10.65 | 8.55 | 48.54 |
| Fallon | 5.67 | 7.46 | 5.24 | 5.36 | 9.64 | 8.89 | 6.07 | 48.33 |
| Yuma | 7.29 | 9.00 | 5.46 | 4.78 | 9.44 | 9.00 | 7.62 | 52.59 |
| $\Sigma e$ | 76.99 | 108.86 | 56.44 | 59.76 | 129.82 | 116.88 | 81.75 | |
| $\Sigma e/\Sigma n$ | 0.87 | 0.99 | 0.92 | 0.86 | 0.94 | 0.92 | 0.86 | |

each period being given at the foot of the table and designated as $\Sigma e$.

In comparing the evaporation during 1912 with the normal evaporation, two procedures have been followed. *First*, the ratio $(\Sigma e/\Sigma n)$ of the total evaporation occurring at all of the stations during a given month in 1912 to the normal evaporation for that period has been calculated (Table II). *Second*, the ratio of the

evaporation at a given station during a given month in 1912 to its normal evaporation for the corresponding period has been determined, and the mean of these ratios for all stations for each month has been computed, together with the probable error. These results are given in Table III. The results of the two methods of comparison will be seen to be in good agreement. The mean value is given in Table IV, with the corresponding ratios

TABLE III

RATIO OF THE MONTHLY EVAPORATION IN 1912 AT EACH STATION TO THE NORMAL EVAPORATION

| STATIONS | APRIL | MAY | JUNE 1-15 | JUNE 16-30 | JULY | AUGUST | SEPTEMBER |
|---|---|---|---|---|---|---|---|
| Amarillo, Tex. | 0.93 | 1.09 | 0.95 | 0.73 | 1.13 | 1.05 | 0.81 |
| Dalhart, Tex. | 1.04 | 1.05 | 0.81 | 0.61 | 1.05 | 0.91 | 0.82 |
| Garden City, Kans. | 0.89 | 1.24 | 1.03 | 0.69 | 1.06 | 0.99 | 0.92 |
| Hays, Kans. | 0.89 | 1.14 | 0.74 | 0.71 | 1.10 | 1.04 | 1.01 |
| Akron, Colo. | 0.86 | 1.03 | 0.71 | 0.87 | 0.81 | 0.82 | 0.68 |
| North Platte, Neb. | 0.80 | 1.12 | 0.75 | 1.00 | 1.06 | 0.96 | 0.82 |
| Newell, S. Dak. | 1.01 | 0.99 | 1.06 | 1.00 | 0.86 | 0.88 | 0.67 |
| Edgeley, N. Dak. | 0.95 | 0.94 | 1.04 | 0.78 | 0.82 | 0.72 | 0.64 |
| Dickinson, N. Dak. | 0.89 | 0.92 | 0.89 | 0.89 | 0.83 | 0.94 | 0.75 |
| Williston, N. Dak. | 0.82 | 0.78 | 1.14 | 0.81 | 0.75 | 0.80 | 0.77 |
| Judith Basin, Mont. | 0.64 | 0.77 | 0.96 | 1.13 | 0.78 | 0.89 | 0.90 |
| Nephi, Utah | 0.74 | 0.87 | 0.99 | 1.05 | 0.96 | 0.96 | 1.00 |
| San Antonio, Tex. | 0.69 | 1.16 | 0.80 | 0.72 | 1.10 | 1.12 | 1.13 |
| Fallon, Nev. | 0.92 | 0.89 | 1.06 | 1.07 | 0.88 | 0.88 | 0.99 |
| Yuma, Ariz. | 0.87 | 0.82 | 0.92 | 0.86 | 0.83 | 0.81 | 0.93 |
| Mean | 0.86 | 0.99 | 0.92 | 0.86 | 0.93 | 0.92 | 0.84 |
| Probable error | ±0.019 | ±0.025 | ±0.023 | ±0.028 | ±0.024 | ±0.019 | ±0.026 |

for the temperature and sunshine. Sunshine records were not available at all the evaporation stations, and the ratios given were obtained from Weather Bureau records for 30 stations in the region in which the evaporation tanks were located.

It will appear from the ratios given in Table IV, that the evaporation during 1912 was abnormally low. The evaporation during April was 14 per cent below normal. However, the average number of hours of sunshine during April was also 7 per cent

below normal, which would account at least in part for the diminished evaporation. May was normal, both with respect to evaporation and hours of sunshine. The evaporation for the first half of June, during which the eruption of Mt. Katmai occurred, was 8 per cent below normal; the second half of June was 14 per cent below normal; July, 6 per cent below; August, 8 per cent below; and September, 15 per cent below. The number of hours of sunshine was also somewhat below normal during this period. The Weather Bureau sunshine records are obtained with the Marvin sunshine recorder, which is essentially a differential thermometer in vacuo, one bulb being blackened. When the rate, at which solar radiation is received, is sufficient to develop a certain difference in the temperature of the bulbs, the sun is recorded as shining.[*] It is evident that any reduction in the intensity of the solar radiation in midsummer (due to dust in the atmosphere or other

TABLE IV

Ratio of the Evaporation, Sunshine, and Temperature in 1912 to the Corresponding Normals

| | April | May | June 1-15 | June 16-30 | July | August | September |
|---|---|---|---|---|---|---|---|
| Evaporation.. | 0.87 | 0.99 | 0.92 | 0.86 | 0.94 | 0.92 | 0.85 |
| Temperature. | 1.00 | 1.03 | 0.95 | 0.96 | 0.97 | 0.98 | 0.88 |
| Sunshine..... | 0.93 | 1.01 | 1.01 | | 0.93 | 0.97 | 0.92 |

causes) would enter into the records from this instrument as a reduction in the number of hours of sunshine. The observed reduction in sunshine (Table IV) following the eruption may therefore be attributed, in part at least, to a reduction in the intensity of the solar radiation transmitted by the upper atmosphere, rather than to an actual increase in cloudiness. There is obviously no way of separating these two factors from a consideration of the sunshine records alone.

It thus appears that the average evaporation as measured at 15 stations was below normal during the four months following the eruption of Mt. Katmai, the average reduction in evaporation being about 10 per cent. This is somewhat less than the observed reduction in the intensity of solar radiation as reported

by Abbot and Fowle and by Kimball, if we assume that for small changes in radiation, the evaporation is directly proportional to the radiation received. In this connection, it should be recalled that the pyrheliometer measurements deal only with the direct rays of the sun. Since the scattered radiation would be proportionately somewhat increased by the dust, the actual reduction in radiant energy during 1912 was probably not quite so great as indicated by the solar measurements. This would tend to bring the results more nearly in accord with the evaporation measurements.

In addition to measurements of the energy of the direct solar beam, Abbot and Fowle[4] have also measured the total sky radiation and the absorbed radiation. In former years, the sum of the three parts of the solar radiation has found to fall below the value of the solar constant by not more than 0.05 calorie. Their measurements in 1912, however, show an outstanding difference of about 0.28 calorie, which they attribute to the greater diffuse reflection of the atmosphere resulting from the haziness. This amounts to a reduction in the intensity of the solar radiation at the earth's surface of about 10 per cent, a value which is in good agreement with the observed diminution in evaporation. The reduction in the mean evaporation at the 15 observing stations following the haze of 1912 thus appears to afford an approximate measure of the reduction in the intensity of the solar radiation at the earth's surface.

RADIOTELEGRAPHY.—*A crystal contact disturbance preventer for radiotelegraphic receiving.* L. W. Austin, U. S. Naval Radiotelegraphic Laboratory.

In 1908 I published the results of a study of the rectifying action of certain contacts, silicon-steel, carbon-steel, and tellurium-aluminum. Soon after this it occurred to me that the property of rapid change of resistance with impressed voltage shown by these contacts might be made use of in shunting to earth loud interfering signals and atmospheric disturbances, so trouble-

[4] loc. cit., p. 13.

some in radiotelegraphic receiving, and in the spring of 1909 very encouraging results were obtained from a tellurium-aluminum contact placed around the primary of the receiving transformer.

It was found however, that in actual service, while occasionally remarkable results were obtained in cutting out disturbances, the tellurium-aluminum contact was too unstable to be depended upon. Silicon in contact with metals was found to be less sensitive than the tellurium contact and also too unstable for practical use. Iron pyrites, zinkite, galena, and many other crystals have been tried at various times and unsuccessful experiments were also made with the Lodge-Muirhead mercury

TABLE I

| DISTURBANCE PREVENTER | |
| --- | --- |
| IN | OUT |
| Deflection | Deflection |
| *mm.* | *mm.* |
| 0.5 | 0.5 |
| 1.5 | 1.5 |
| 3.5 | 4.5 |
| 7.0 | 22.0 |
| 15.0 | 130.0 |
| 21.0 | 240.0 |
| 40.0 | off scale |
| 2.5 | 2.5 |

coherer, several other types of coherers, with vacuum valves and the electrolytic detector. It has recently been found that silicon in contact with certain crystals, especially with metallic arsenic, of which the dark colored impure variety is the best, forms a practical device for leading strong disturbances to earth without interfering with the reception of the regular signals.

Table I shows the detector galvanometer deflections with the disturbance preventing circuit in and out, the antenna being excited by a tuned buzzer circuit with different degrees of closeness of coupling.

Table II shows the relation between tuned buzzer circuit signals and natural atmospherics, the maximum throw of the

galvanometer during a period of 10 seconds being taken as the atmospheric reading.

The disturbance preventer is more effective in the case of strong interfering signals than against atmospheric disturbances, as it is quite possible to read signals of twenty times audibility thru disturbing signals of many hundred times audibility on the same wave length. The best results are obtained with loose coupling and with a considerable amount of inductance in the antenna, with a series condenser if necessary, and the disturbance preventer contact shunted across only that part of the inductance which acts as the primary of the receiving transformer.

TABLE II

| Disturbance Preventer In — Deflection mm. | | Disturbance Preventer Out — Deflection mm. | |
|---|---|---|---|
| *Signal* | *Atm.* | *Signal Approx.* | *Atm.* |
| 10 | 7 | 12 | 51 |
| " | 7 | " | 80 |
| " | 6 | " | 75 |
| " | 8 | " | 62 |
| " | 6 | " | 68 |

An increase of the effect may be obtained by throwing the circuit out of tune to the loud signals by placing disturbance preventers across the capacity or across other portions of the inductance, and also in the secondary circuit. But in general, except under extraordinary circumstances, these introduce complications in handling which are out of proportion to their benefit.

Fairly good results have been obtained also with a contact of carborundum with other crystals. These combinations however, while more stable under extremely powerful disturbances, in general do not fall low enough in resistance to give as satisfactory results as the silicon-arsenic. I wish to express my indebtedness to my assistant, Chief Electrician Mineratti in the latter portions of this work.

GEOPHYSICS. *Data on the intrusion temperature of the palisade diabase.* R. B. SOSMAN and H. E. MERWIN, Geophysical Laboratory.

In his report on the petrography of the Newark igneous rocks of New Jersey,[1] Prof. J. Volney Lewis has described an interesting type of inclusion which occurs frequently in the Palisade diabase. Slabs of the underlying Newark shale and arkose sandstone have been "floated" up into the igneous rock until they stand at various angles between horizontal and vertical. In connection with an investigation on the specific volumes of rocks at high temperatures it became of interest to compare the specific volumes of the included and including rocks in this type of inclusion. Professor Lewis very kindly supplied us with specimens for the purpose, and our indebtedness to him both for material and for published descriptions is here acknowledged.

The specimens first obtained were from the quarry of the Fairview Stone Crushing Company, at the north end of the diabase hill between Fairview and Granton, New Jersey. This mass is an offshoot of the great Palisade sill which outcrops along the west bank of the Hudson River and extends southwest thru New Jersey. It lies only 800 feet west of the western border of the main sill, and is not over 200 feet vertically above the upper surface of this sill.[2]

In 1907 there was visible in the quarry mentioned "an arkosic sandstone slab about 10 feet thick at one end and tapering to about 5 feet at the other and over 100 feet long, lying at an angle of about 10 degrees with the horizon. This inclusion is within 10 feet of the bottom of the diabase sheet, which here rests on thinly laminated black and gray shales." We are informed by Professor Lewis that since that time quarrying operations have followed this slab back until it joined the underlying strata, thus establishing its connection with the floor of the intrusive mass. It was, therefore, not possible to obtain specimens of the actual inclusion, but specimens of the underlying arkosic sand-

[1] Geol. Surv. New Jersey, Ann. Rep., 1907, pp. 97-167. See, in particular, pls. 27 and 28, and p. 135.

[2] J. V. Lewis, Geol. Surv. New Jersey, Ann. Rep., 1906, p. 122; H. B. Kuemmel, ibid., 1897, p. 73.

stone and shale, apparently continuous with the floated slab, were obtained.

A preliminary experiment, made by heating specimens of the diabase and the arkose side by side in a platinum crucible, showed that at a temperature where the diabase would flow readily, the sedimentary rock was also partly fused, altho in the original inclusion there was no indication of fusion. The authors therefore undertook, as a side issue to the main question of the volume relations, a brief study of the relative fusing temperatures of the rocks in question. The results, while necessarily incomplete because of the complexity of the rocks and the unknown factors involved, show that the temperature at which the diabase was intruded must have been considerably lower than the temperature necessary to liquefy this diabase in the laboratory. This fact has long been suspected, altho there has been hitherto very little quantitative evidence bearing on the question.[3]

*The diabase.* There is no published analysis of the rock from this particular locality, but the rock is very similar to the "basaltic diabase" in the near-by railroad tunnels thru the Palisade sill, and to that of Rocky Hill.[4] Mr. Hostetter's determinations on our specimen gave 0.6 per cent water at 105°, 8.74 per cent FeO, and 1.51 per cent $Fe_2O_3$. The character of the rock would be approximately represented by the following weight percentage composition: $SiO_2$ 51, $Al_2O_3$ 13, CaO 10.5, MgO 7.5, FeO 8.5, $Fe_2O_3$ 1.5, alkalies 3.5, $TiO_2$ 1., water and miscellaneous 1.5. Its density at 20° was 2.97.

The rock is fine grained, and consists of a dense holocrystalline mass of feldspar and augite, with phenocrysts of pyroxene and of plagioclase feldspar. Minor minerals are biotite, magnetite, and occasional olivine.

*Fusion of the diabase.* The tests were made by placing small fragments of the rock, wrapped in platinum foil, in an electrically heated furnace held at a constant known temperature, measured by a thermoelement and potentiometer. After exposure to this

[3] See F. E. Wright, Intrusive Rocks of Mt. Bohemia, Geol. Surv. Michigan, Ann. Rep., 1908, p. 391.

[4] Geol. Surv. New Jersey, Ann. Rep., 1907, p. 121, analysis 4, 5, and 12; and pl. 16. Description, pp. 126-128.

temperature for a measured time, the rock was quenched by fusing off its supporting wire and dropping it out of the furnace into a basin of mercury. Microscopic examination then showed what changes had taken place at the high temperature. A fresh fragment was of course used for each test.

The lowest temperature at which tests were made was 751°. After the diabase had been held at this temperature for fifteen minutes, and then quenched in mercury, the phenocrysts of feldspar and pyroxene showed no change whatever; in the augitic groundmass a red brown mineral had formed, having an index of refraction of 1.74 and resembling certain basaltic hornblendes high in ferric iron.

There were no indications of fusion at 751°, nor at 850°, 953°, 1035°, 1052°, and 1101°. Fragments of the rock were held fifteen minutes at the first four of these temperatures, and seventy-five minutes at the last two. All gave practically the same result as the quenching at 751°, except that the red brown mineral decreased in amount with rising temperature. A dusty yellow-brown material which could not be identified, appeared in small amount at 1101°.

After seventy-five minutes at 1150° the phenocrysts were still unchanged, but the clear red-brown hornblende (?) had disappeared. A dusty yellow-brown substance, too dark for the determination of its optical properties, appeared to coat other minerals in films, and showed a few bubbles in places. Its occurrence suggested strongly the beginning of fusion of the lowest melting portion of the rock. Fifteen minutes at 1175° gave a little dark glass which could be positively identified, so that we may take 1150° as the approximate beginning of the temperature-interval of fusion. Feldspar and pyroxene phenocrysts remained unchanged at 1175°.

Fifteen minutes at 1200° produced considerable brownish bubbly glass of refractive index 1.60–1.61, and fused nearly all the pyroxene phenocrysts. Seventy-five minutes at the same temperature practically removed the pyroxene and gave a more homogeneous glass, none having refractive index above 1.60. The feldspar phenocrysts, except around their borders, remained unchanged.

The fragments of rock had an external appearance of incipient fusion.

Seventy-five minutes at 1225° caused the fragment to flow. About a third of the feldspar remained; the remainder was glass, containing dark brown octahedral and cubic grains which formed out of the glass. These grains had the high refraction of spinel. Heatings of fifteen and sixty minutes at 1250° fused or fluxed still more of the feldspar but did not remove it entirely. Fifteen minutes at 1302° left only traces of feldspar, and produced a clear glass, of refractive index equal to and slightly less than 1.60.

With its present composition, therefore, and under atmospheric pressure the diabase can not flow at a temperature below 1150° (at which temperature the lowest melting portion probably fuses), and does not flow appreciably below 1225°. It is completely liquid at about 1300°.

*The inclusions.* These consist both of feldspathic sandstone and shale. "The thinner portions of the sandstone inclusions are very hard and compact, and look in all respects like fine-grained, light colored granite. . . . From this facies every gradation is found to apparently normal feldspathic sandstone (arkose) in the thicker portions, showing little sign of alteration."

*Fusion of included arkose.* We obtained from Professor Lewis a specimen of arkose which had been entirely surrounded by coarse grained diabase under conditions where it must have taken up the temperature of the molten rock, and so situated that it could not have been traversed by mineralizing solutions after the solidification of the rock. This specimen was from the Palisade sill, in the Pennsylvania Railroad cut east of Marion station, Jersey City, where "thin sheets of arkosic sandstone, perhaps originally continuous, lie in an irregular undulating position in the diabase."[5] This inclusion varies in thickness from 4 inches to 3 feet (10–90 cm.). The fragments examined were not over 2 cm. from the diabase.

The metamorphosed arkose consists chiefly of quartz and orthoclase. New growth of orthoclase is visible around some of the original grains. It is all somewhat dusty, probably from subsequent alteration, altho biotite and hornblende, also present,

[5] J. V. Lewis, loc. cit., 1907, p. 135, (4), and pl. 28.

are very fresh. The latter minerals and magnetite appear to have originated chiefly from chloritized biotite originally present in the arkose, altho the surrounding magma may have contributed to their growth. One of the specimens showed, in a small cavity, well terminated crystals of quartz, orthoclase, and hornblende, apparently outgrowths of these minerals in the arkose. Calcite and datolite, which are found in some parts of the underlying arkose, are not found in this inclusion.

The characteristics just mentioned show that this rock could never have been fused. The retention of original cross-bedding in another specimen[6] is certain proof that the arkose could not have flowed.

Heated for thirty minutes at 1023°, this arkose showed no trace of glass. The biotite and hornblende were destroyed, feldspars more clouded, magnetite and quartz unchanged. After seventy-five minutes at 1150° the rock was more than half fused to a bubbly glass of refractive index 1.490 to 1.502. The feldspars were all fused, and only quartz and magnetite remained. Such a rock containing unaltered feldspar might fuse at a somewhat different temperature, but inasmuch as the feldspar was altered in part before the intrusion of the diabase the temperatures here observed are applicable.

*Fusion of underlying arkose and shale.* As mentioned above, we also obtained thru Professor Lewis specimens of the underlying arkose and shale at Granton, and it was upon these that the preliminary fusion tests were made. It was only after several measurements had been made on both rocks that datolite (which does not occur uniformly, and is sometimes entirely absent) was found in the arkose. Its presence renders the tests on these rocks inconclusive, but the results are included as a matter of record.

Our specimen of the underlying arkose at Granton consisted of about two-thirds alkali feldspars and nearly one-third quartz, with some augite, the latter being in crystals partly inclosing feldspar and quartz, as tho derived from constituents of the near-by diabase and from chloritized biotite present in the arkose before the intrusion. The feldspars had clear borders which had evi-

[6] Loc. cit., 1907, p. 135, (3).

dently grown upon the original feldspar grains, partly filling the pores of the rock with fresh feldspar. Calcite and datolite also occurred as pore-filling minerals.

Heated for fifteen minutes at 950°, the arkose showed no external change. A small amount of glass was found, formed by the fusion of datolite. The quartz appeared unchanged. After fifteen minutes at 1150°, glass was again present, resulting as before from fusion of datolite. Seventy-five minutes at the same temperature produced 10 to 15 per cent of glass of index 1.50–1.52. The orthoclase had begun to fuse around the edges of crystals and around the inclusions contained in the crystals.

Our specimen of the underlying shale was a very fine grained rock of density 2.59, banded with white and blue-black streaks, and having coarser lenses containing garnet. In the white portion quartz was identified, and probably andalusite.

Heated for fifteen minutes at 950°, the finest grained parts of the rock showed no marked change and no glass could be found. Fifteen minutes at 1150° caused the fragment to flow, and seventy-five minutes at the same temperature converted over one-half of it into glass of refractive index 1.51 and less, with a few fragments of original quartz remaining. But the extremely fine grain of the rock rendered it unsatisfactory for these experiments.

Both the shale and the arkose just described contained minerals of secondary origin resulting from the intrusion. Some of these probably formed during the period of cooling; therefore effects produced by heating these rocks might be quite different from those which might have been caused at the same temperature in the original rock.

*Conclusion.* The foregoing facts may be summarized in the following statements: (1) The "basaltic" facies of the Palisade diabase begins to fuse at about 1150°, and enough of it is fused at 1225° to permit the rock to flow; (2) The arkose now found in the diabase in the form of inclusions is more than half fused at 1150°, but shows no fusion at 1025°. (3) These inclusions as actually found show no indication of fusion or flow.

*As indicated by their present properties* under atmospheric pressure, there is therefore a gap of at least 100°, and probably more, between the maximum temperature to which the arkose inclusions

could have been subjected, and the minimum temperature at which the diabase could have flowed. At the time of intrusion, therefore, either the fusion temperature of the arkose minerals was greatly raised by the conditions then existing, or the fusion temperature of the diabase was lowered, or both causes acted together.

From experiments not yet published, we know that there is a considerable net volume increase accompanying the fusion of the diabase; its mean temperature of fusion would therefore probably be *raised* by increased pressure. About the volume change of the arkose minerals we know nothing; but from geological evidence the depth of overlying rock was probably not great, in comparison with the depths and pressures necessary to produce large changes in their fusion temperatures.

The most likely agent that suggests itself to bridge the gap between the laboratory fusion temperature of the arkose and that of the diabase is the water which the evidence of the surrounding rocks shows to have been present in the magma. Its effect in lowering the fusion temperatures of silicates is quantitatively unknown, but qualitatively we know it may be very large. Other factors of perhaps less importance are the boric acid now found in the datolite of surrounding rocks, and the carbon dioxide and fluorine which may have been present.

The foregoing investigation may serve to emphasize a point which is all too frequently overlooked in current speculation on the fusion of rocks on the basis of the laboratory data now available. The conditions of fusion, differentiation, intrusion, and crystallization may have been modified, not slightly but profoundly, by volatile components of which only occasional traces are retained in the rock as we find it at the surface of the earth. To draw final conclusions, then, on the basis of any property possessed by a particular rock type or even by a particular specimen may lead us widely astray. This is not to say that the problems involving the effect of volatile components can not be solved, for experimental methods have been and are being worked out to handle them; but until we know in what directions and to what extent these volatile ingredients have modified the conditions of rock formation, extended generalisation is hazardous and of doubtful utility.

PHYSICS.—*An electrical goniometer furnace for the measurement of crystal angles and of refractive indices at high temperatures.* FRED. EUGENE WRIGHT. Geophysical Laboratory.

The measurement of the change in the optical properties and in the interfacial angles of crystals with change in temperature has long interested mineralogists, and many attempts have been

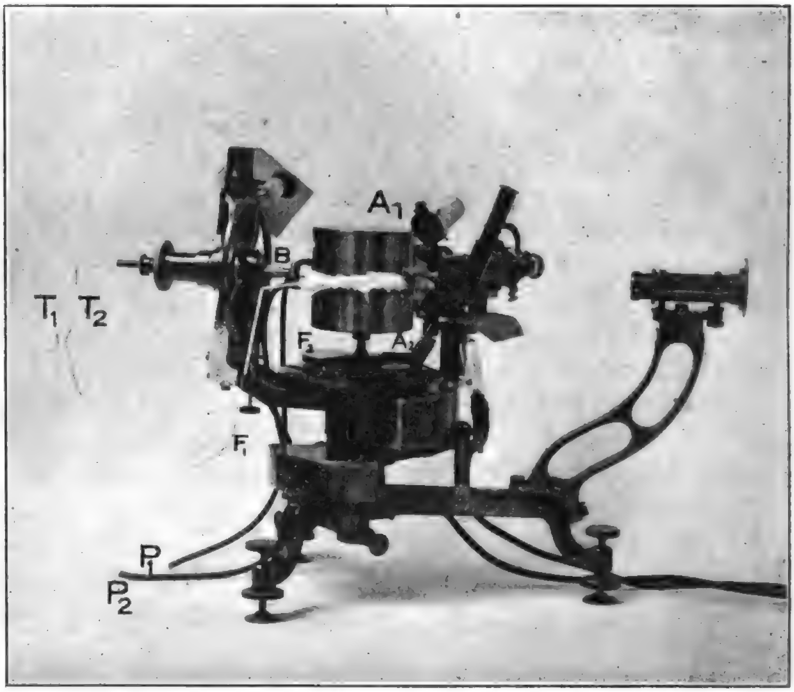


Fig. 1. Photograph of Goldschmidt's two circled goniometer with thermoelectric furnace attachment mounted in position ready for measurements. $A_1, A_2$, upper and lower water jackets; $P_1, P_2$, rubber tubing for circulation of water thru $A_1, A_2$; $F_1, F_2$, platinum wires, 0.4 mm. in diameter, of heating spirals in furnace; $B$, crystal holder extending into center of furnace; $T_1$, $T_2$, thermoelement wires.

made, since the pioneer work of Schrauf and Mallard, to devise satisfactory methods for the purpose. The introduction of electrical methods and appliances has greatly simplified the problem and recently F. Rinne[1] has successfully adapted an electric re-

[1] Neues Jahrb. Min. Geol. u. Pal., 1910, II, 139.

sistance furnace to the measurement of the refractive indices of prisms at temperatures up to 750°C. In the different heating devices, however, which have heretofore been employed, insufficient attention has been given to the furnace design with reference especially to the heat distribution and to accuracy of the temperature measurements, with the result that the data obtained are encumbered with unnecessarily large prob-

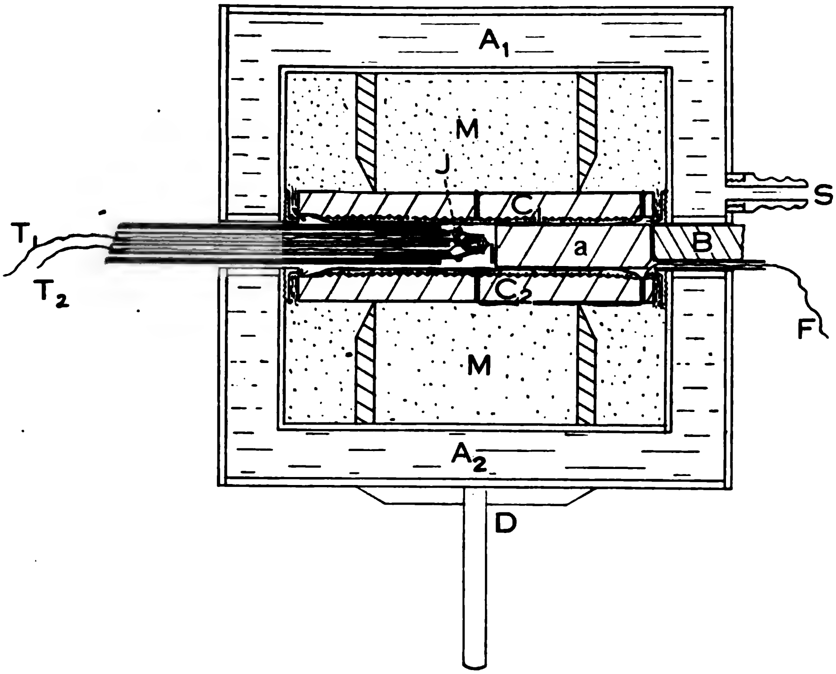


Fig. 2. Vertical section thru furnace and water jacket; $A_1$, $A_2$, water jackets; $S$, intake for circulating water; $F$, platinum furnace wires; $C_1$, $C$, alundum cake on inner faces of which platinum wire spiral is wound; a, alundum segment; $B$, asbestos ring; $J$, bare thermal junction; $I$, crystal; $M$, magnesium powder; $D$, supporting bar of furnace; $T_1$, $T_2$, thermoelement wires.

able errors. In the present furnace, the effort has been made to meet these objections and to produce an instrument of fair precision which may serve not only for the measurement of the interfacial angles of a crystal, but also for the direct measurement of its refractive indices at any temperature up to 1150°C., at

which temperature the light of the furnace becomes relatively intense and the measurements are correspondingly less satisfactory.

The furnace fits as an attachment on the Goldschmidt two-circled goniometer (fig. 1, *A*). It consists of two flat disks of alundum (7 cm. in diameter and 5 mm. thick) on one side of which a spiral of 1.75 mm. pitch is stamped;[2] into its grooves platinum wire 0.4 mm. thick is wound and then covered with a

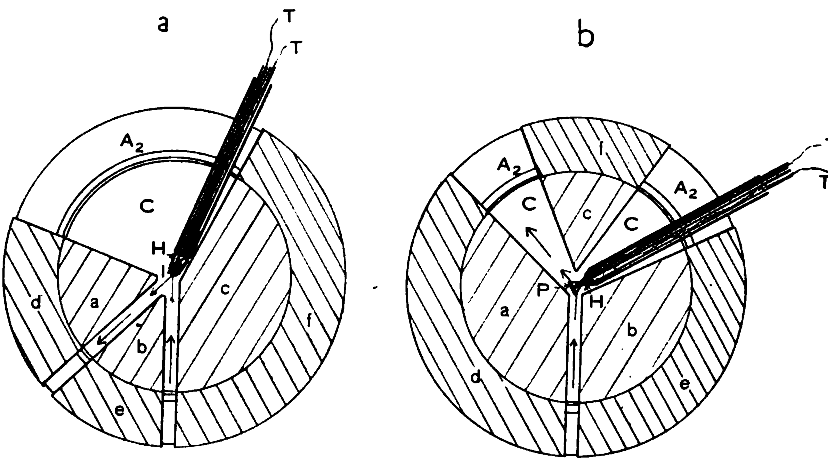


Fig. 3. Top view of furnace after water jacket $A_1$ has been removed. Figure 3a shows arrangement of alundum segments, *a*, *b*, *c*, of asbestos ring segments *d*, *e*, *f*, of crystal holder *H*, of crystal *I*, and of thermoelement wires *T*, in case the furnace is used for measuring interfacial crystal angles. The arrows indicate the paths of the rays from collimator to crystal and then to telescope of the goniometer. In figure 3b, the arrangement is sketched for the case of the measurement of the refractive index of the prism P by the minimum deviation method. The letters have the same significance as in figure 3*a*.

thin layer of alundum cement and baked at 1200° to 1300°C. These disks are backed by magnesia powder and mounted in hollow cylindrical water jackets (fig. 2) Their edges are shielded from direct contact with the water jackets by asbestos wool packing. The details of construction are evident from figures 1 and 2. Segments of alundum 10 mm. thick and of the shapes indicated in figure 3, *a*, *b*, *c*, are placed in position on top of furnace

[2] Made on special order by the Norton Company of Worcester, Mass.

cake $C_2$, and serve to support the upper furnace part $A_1$, (figs. 1 and 2). Outside of these segments asbestos ring segments are fitted as indicated in figure 3, *d*, *e*, *f*. Since alundum is a good conductor of heat the alundum segments tend effectively to render the heat distribution uniform at the center of the furnace while the outside asbestos rings are poor conductors and tend to confine the heat properly. In figure 1 asbestos wool has been used in addition to the asbestos rings as an extra precaution. The furnace opening at the crystal holder *B* is also shielded to some extent by asbestos wool.

Heat is supplied thru the wires, $F_1$, $F_2$ (fig. 1), 4.5 to 5 amperes' current at 110 volts being required to heat the furnace to 1150°. Cold water passing thru the tubes, $P_1$, $P_2$, (fig. 1) and and the water jackets, $A_1$, $A_2$, completely protects the goniometer parts from the heat. Temperatures are read by means of the thermoelement ($T_1$, $T_2$, fig. 1) either on a millivoltmeter of the Siemens and Halske type or on one of the potentiometer-galvanometer systems of this laboratory.

In order to adapt the two circled goniometer to such measurements a special carriage (fig. 1,*B*) was made to replace the usual crystal centering and adjusting carriage. This part is hollow and into it a porcelain tube is inserted on the end of which small platinum jaws are fitted, similar to those used in the thermal microscope recently described.[3] In these jaws the crystal is mounted and adjusted before the furnace parts are set in position. Thru the carriage B and the porcelain tube holder the thermoelement wires (0.2 mm. in diameter and enclosed in fine porcelain tubes) pass and are so adjusted that the bare thermal junction of the thermoelement is in direct contact with the crystal.

After the crystal has been adjusted and centered approximately in the platinum jaws, the furnace part $A_2$ is raised to about the position indicated in figure 2. The alundum and asbestos ring segments are then put into position and the upper furnace $A_1$ placed on them. After the proper electric and water

[3] This Journal, **3**: 232–236. 1913.

jacket connections have been made, the furnace can be carried to any temperature up to 1150° and the crystal angles or the refractive indices of a prism measured by the ordinary room temperature methods which are in general use. As the crystal is enclosed in the furnace a dark room is not necessary for the measurements.

As noted above the adjustment of the crystal or prism is done practically by hand both by moving and tilting the crystal slightly and by bending the platinum jaws as a whole. In the present apparatus this procedure is often tedious and it is planned to modify the present adjustment device so as to facilitate this part of the procedure. For crystal angle measurements this adjustment is unnecessary because the theodolite principle is there used and any direction in the crystal may serve as a pole, the proper reduction of the observed position angles being made later by routine calculation. The arrangement of the alundum segments in the furnace for the measurement of crystal angles is indicated in figure 3a, while that for measuring the refractive indices of properly oriented crystal prisms by the minimum deviation method is shown in figure 3b. The methods of measurement followed are the standard room temperature methods and need not be described here.

It may be of interest to note that recent preliminary measurements in the goniometer furnace on a cleavage rhomb of calcite indicate that the cleavage angle of calcite at 600°C is 75°52′, while at room temprature (30°) it is 74°55′, a change in the cleavage angle of nearly one degree during a temperature rise of about 600°. At 700° the calcite crystal faces lose their lustre and become white (formation of CaO) and are valueless for goniometric work. The above change in cleavage angle indictes an average increase of 1 minute in angle for every 10° temperature rise. It would seem, therefore, that the practice of expressing crystal angles to seconds of arc without giving the temperature at the time of measurement can serve little purpose and is in fact illusory as regards the actual accuracy implied.

An extended series of measurements of the change of the optical properties and crystallographic angles of the rock making

minerals with temperature rise has been commenced at the Geophysical Laboratory—the birefringence, extinction angles, and optic axial angles being measured on the new thermal microscope while the refractive indices and crystal angles are measured on the thermoelectric goniometer furnace. In each case only minerals of definitely known composition are to be taken and the temperatures of melting and of inversion controlled by the heating and quenching methods now in use in this laboratory. Accurately oriented crystal sections are to be ground on a new crystal grinding goniometer which is now practically finished in the workshop of the laboratory. With this instrument, in which the device for autocollimation described recently in this Journal[4] has been adopted, it will be possible to orient and to grind crystal plates with reference either to their crystallographical directions or to their optical directions.

So far as can be judged from preliminary measurements, the results obtained with the electrical goniometer furnace on favorable material, are accurate to about 5° in temperature, about 1′ in crystal angle readings and 1 or 2 in the fourth decimal place in refractive index measurements.

The three instruments—new thermal microscope, goniometer furnace attachment, and crystal grinding goniometer—render possible the quantitative study of crystallography and of mineral optics at high temperatures. Such study should add materially to an understanding of the crystallographic forces and of their relation to other physical forces, such as internal friction and surface tension.

[4] This Journal, 3: 235. 1913.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

ASTRONOMY.—*Determination of time, longitude, latitude and azimuth.* WILLIAM BOWIE. Special Publication No. 14 of the U. S. Coast and Geodetic Survey, 1913.

This is the latest issue of a series of manuals prepared by the U. S. Coast and Geodetic Survey for the guidance of the astronomic observer in the field and the computer in the office, in carrying on the geodetic astronomy of the Survey in a systematic manner.

This publication necessarily contains much data that appeared in the fourth edition but there is also much new material, the principal items of which are: The determination of time and longitude, using the transit micrometer; a description of the transit micrometer; determination of time with the vertical circle for use in connection with azimuth observations; a description of the method of observing azimuth coincidently with horizontal directions in primary triangulation; an example of the determination of an azimuth in Alaska with a transit equipped with a transit micrometer; examples of the records and computations in the different classes of work, as actually made at present by the Survey; and statements of the field cost of the different classes of work.

W. BOWIE.

GEODESY.—*The California-Washington Arc of Primary Triangulation.* A. L. BALDWIN. Special Publication No. 13, U. S. Coast and Geodetic Survey, 1913.

In the spring of 1903 the U. S. Coast and Geodetic Survey began the reconnaissance for an arc of primary triangulation to extend from the primary triangulation in northern California to Puget Sound. The work of reconnaissance was not done continuously in any one season,

but was done a little at a time, in order to interfere as little as possible with the observations. The observing was completed in four summer seasons, beginning in June, 1903, and ending in July, 1906.

The length of the primary triangulation of this arc, along the axis of the scheme, is 577 miles (929 kilometers) and the length of the subsidiary schemes, secondary in character, is about 30 miles (48 kilometers). Fifty-seven stations constitute the main scheme. The mean latitude of the three old stations of the Thirty-ninth Parallel triangulation, from which the arc started, is 39° 05′, and the northernmost point lies in latitude 47° 23′. The triangulation follows closely the meridian of 122° 30′.

There were used to control the lengths in this triangulation the Yolo base in California, the Willamette base, near Eugene, Oregon, and the Tacoma base, near Tacoma, Washington. The Yolo base was measured in 1881 in connection with the transcontinental triangulation, while the other two bases were measured in 1906.

Each of the triangulation stations was well marked and hence is available for the surveyor and engineer. The publication contains descriptions of the location and marking of the stations, also the latitude and longitude of each point in the scheme and the azimuth of each line observed over for horizontal directions.

A series of sketches and an index enable one to find readily the data for any portion of the area covered by the triangulation. W. Bowie.

GEOLOGY.—*The Onondaga fauna of the Allegheny region.* E. M. Kindle. U. S. Geological Survey Bulletin 508. Pp. 144, with a map and sections.

The Onondaga limestone is represented from Hudson River to Lake Erie by a zone of frequently recurring outcrops across central New York State. Passing under Lake Erie, the fauna reappears in rocks of the same lithologic facies in northern and central Ohio, and reaches as far west as Louisville. The most westerly recorded appearance of the fauna is at the Bake Oven, in southwestern Illinois, so that it has an east-west extension of about 1000 miles. In sharp contrast with this considerable westerly extension of the Onondaga fauna beyond its type region in eastern New York is the comparatively insignificant southerly extension of the fauna and formation as it has been generally recognized. The formation barely crosses Delaware River, according to most of the papers dealing with the stratigraphy of the Devonian in the Allegheny region, which give it a north-south extension of scarcely 200 miles. This

insignificant southerly extension of a fauna which has been recognized as so persistent in a westerly direction seems more surprising when it is recalled that nearly all the other faunas characterizing the major divisions of the New York Devonian section have been traced southward from New York entirely across Pennsylvania into the Virginias. Thus, it is seen that the prevailing conception of the Onondaga fauna, which presumes its absence south of New York, gives to it an anomalous position as compared with the other important faunas of the Devonian section of New York. The evidence gathered during several seasons of field work in the Allegheny region indicates that this conception is not well founded, and that the southerly extension of the Onondaga fauna is quite comparable in distance with its westerly extension. The field studies have shown that the Onondaga fauna in the Allegheny region extends far south of the area in which nearly pure limestones were deposited during Onondaga time, into a region where shale-forming sediments partly or completely dominated those of calcareous type. This fauna has been found in nearly all the sections studied from New York to Tennessee.

The direct bearing of these new data on the paleography of Onondaga time is obvious. They indicate the extension of the eastern shore line of the Onondaga sea in a southwesterly direction from southeastern New York to the east of the Allegheny region instead of far to the west of it, as previously drawn in paleogeographic maps, across the States of Ohio, Indiana, and Kentucky. In the light of this new evidence it appears that the eastern shore line of the Onondaga sea trended southwestward across north-central New Jersey and southeastern Pennsylvania. It probably traversed the States of Maryland and Virginia near the present axis of the Blue Ridge. From southwestern Virginia this shore line appears to have trended westward not far from the Kentucky-Tennessee line as far as the valley of Tennessee River, where it resumed its southerly trend. E. M. K.

ENTOMOLOGY.—*Three interesting butterflies from eastern Massachusetts.* Austin Hobart Clark. Proceedings of the United States National Museum, **45**: 363–364; pls. 32.

*Junonia cœnia* Hübner is recorded from Newtonville and from Coffin's Beach, near Annisquam; *Feniseca tarquinius* (Fabricius) is recorded from Newtonville; and a specimen of *Euphydryas phaëton* (Drury) from Newtonville representing the variety *superba* Streker is described and figured. A. H. C.

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SEPTEMBER 19, 1913.

# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES



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# JOURNAL

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# WASHINGTON ACADEMY OF SCIENCES

Vol. III SEPTEMBER 19, 1913 No. 15

OCEANOGRAPHY.—*Observations on ocean temperatures in the vicinity of icebergs and in other parts of the ocean.* C. W. Waidner, H. C. Dickinson and J. J. Crowe, Bureau of Standards.

Thru the courtesy of the Navy Department an opportunity was afforded representatives of the Bureau of Standards to make observations on the temperature of sea water in the vicinity of icebergs and in the open sea with a view to obtaining information on the possibility of detecting the proximity of ice from temperature records.

The Bureau party embarked on the *U.S.S. Chester,* leaving Philadelphia on June 2, 1912, under command of Captain Decker. Mr. Crowe was subsequently transferred to the *U.S.S. Birmingham,* under command of Captain Hughes, and continued observations from June 19, until the return to the port of Philadelphia on July 11, 1912.

*Temperature equipment.* Some of the more important apparatus assembled for these experiments consisted of the following: (1) A surface electrical resistance thermometer, consisting of a flat coil of silk-covered nickel wire inclosed between copper sheets, and insulated by thin layers of mica. The resistance of the nickel coil was about 100 ohms. (2) Deep sea thermometers of the Negretti and Zambra type kindly loaned by the Bureau of Fisheries. (3) Several standard mercurial thermometers. (4) A Leeds and Northrup recorder, suitable for use with the resistance thermometers. This was kindly loaned for these experiments by the Leeds and Northrup Company.

All of the apparatus was carefully calibrated before leaving the laboratory. The surface thermometer was mounted with its flat face directly against the inner surface of the ship's $\frac{3}{8}$-inch plates, about 6 feet below the water line. Simultaneous measurements of temperature, made with a sensitive mercurial thermometer inserted in the water and with the surface thermometer and recorder mounted as above, showed that the sudden changes in sea water temperature were indicated by the recorder without any significant time lag. The suspended system of the D'Arsonval galvanometer of the recorder was so carefully balanced by the makers that the records were entirely unaffected by the rolling and pitching of the ship. As used, a change of 1°C. corresponded to a movement of the pen of 18 mm. on the record sheet. The displacement of the paper was about 60 mm. per hour.

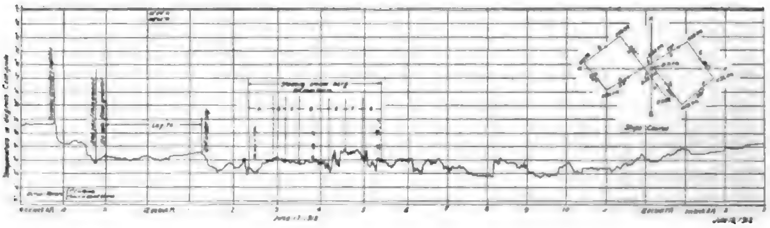

Fig. 1. Record of June 17, 1912

*Temperature records.* Practically continuous temperature records were obtained from June 4 until July 10, 1912. The temperatures recorded ranged from 3° to 25°C. The balance point of the recorder was changed to bring the temperature records on the paper by the insertion of suitable known resistances in one arm of the Wheatstone bridge circuit of the recorder, the calibration of the surface thermometer being made with the corresponding resistances in the circuit.

Figure 1 shows the temperature record obtained on board the *U.S.S. Chester*, June 17, 1912. Several small bergs or "growlers" were sighted on the horizon at 9.45 a.m. Almost simultaneously, the record shows a sudden fall of temperature from 8°.7 to 7°.3 C., or nearly 1°.5 C. At this time the ship was over 10 miles from the nearest of the growlers. The temperature continued to fall irregu-

larly as the growler was approached until 10.45 a.m. when the temperature was 5°.7C., at which time the distance from the growler, estimated by the range finder, was about 500 yards. At 11.00 a.m. the distance was about 150 yards. A party put out in a boat to take observations of temperature around the growler whose mass was estimated at about 12,000 tons. The surface temperature as determined by the observers in the life boat ranged from 5°.8 to 6°.7C.

At 1.20 p.m., the ship steamed toward a large berg about 12 miles distant. The course of the ship around this berg is shown by the diagram in the upper right corner of figure 1. The course *D* is 6 to 7 miles in length. The various legs of this course *A*, *B*, —*G* are also indicated on the temperature record, figure 1. No significance can be assigned to the irregular fluctuations of temperature observed around this berg (see figure 2).

About 5.25 p.m. the ship lay to, abeam of the berg at a distance of 300 yards. A party put out in a small boat for temperature observations. The time until about 7.00 p.m. was spent in the immediate neighborhood of the berg, the ship sailing around the berg, while the party in the small boat was taking observations. From about 7.00 to 9.30 p.m. the ship lay to, during which time the ship and berg drifted apart. The ship then cruised around until midnight in an unsuccessful effort to locate the berg with the aid of two powerful searchlights. From measurements made with two stadimeters, on the ship and on the whaleboat respectively, the mass of the berg was found to be about 400,000 tons.

The mean of a number of temperature observations taken from the whale boat gave the following surface temperatures: 20 feet from the berg 4°.5, 35 feet 4°.9, 50 feet 5°.0, 75 feet 5°.4, 200 feet 5°.7C. The temperature at a distance of 50 feet from the berg and at a depth of 5 fathoms was 3°.6C., and at a depth of 20 fathoms 3°.3. At some miles distant from the berg temperatures were encountered as low as those observed a few feet from the berg.

*Variations in the salinity of sea water.* Variation in the salinity of sea water in the neighborhood of icebergs due to the diluting action of the water resulting from the melting of the ice is so small as to be entirely masked by the accidental variations found

in sea water. The following determinations of the densities of samples of sea water, taken under conditions specified and afterwards tested in the laboratories, serve to illustrate this.

| SAMPLE NUMBER | SPECIFIC GRAVITY AT $\frac{20^\circ}{4^\circ}$ C. | REMARKS |
|---|---|---|
| 1 | 1.02339 | Close to berg |
| 2 | 1.02352 | Close to another berg |
| 3 | 1.02340 | 400 yards from berg |
| 4 | 1.02336 | 40 miles from berg |
| 5 | 1.02319 | 60 miles from berg |
| 6 | 0.99923 | Water from berg ice |
| 7 | 0.99923 | Distilled water |

*Echoes from icebergs.* The testimony of numerous observers is on evidence that the echo of the fog horn may frequently, but by no means always, be detected when in the proximity of an iceberg or even of a bank of fog. The amount of evidence on this point leaves no doubt as to the correctness of the above statement. The experiment of sounding the fog horn when in the vicinity of a number of the bergs encountered on the trip was tried but in no instance was an echo detected. A few experiments were also made to determine whether an echo could be detected under water coming from the larger submerged portion of the berg. For this purpose the ship's bell was lowered into the water and signals produced by striking the bell. Observers stationed at the ship's submarine signal telephones listened for evidences of the echo. The ship was at a distance of 1 to 2 miles from the fair sized berg encountered by the *U.S.S. Chester* on the afternoon of June 17. It was difficult to draw postive conclusions on account of the disturbing noises present in the telephone receiver, but a number of observers were convinced that they heard faint echoes. There was no time to investigate and improve the telephonic apparatus, so that the most that can be said is that these preliminary experiments look hopeful enough to merit more careful experiments.

*Other observations.* The results of other experiments such as firing 3 and 5-inch shells into the berg, the utility of searchlights in locating bergs at night, etc., will undoubtedly be covered in the official reports of the commanding officers. It may be worth

while to record, however, the general impressions of the authors, unfamiliar with such matters, that the effects of cannon fire were disappointingly small and the utility of powerful searchlights surprisingly limited. Altho the lookouts were provided with spy glasses or with binoculars, it is of interest to note that the icebergs were invariably first seen with the unaided eye. The difficulty of picking up icebergs under some conditions is illustrated by the following incident. While the ship was steaming toward a large berg in sight, a heavy fog fell. One lookout was in the crow's nest, four were on the bridge, and two in the ship's eyes. Notwithstanding this the berg was first picked up from the quarterdeck after the ship had passed the berg some 200 yards abeam.

Samples of ice broken from the berg by gun fire were taken aboard ship. These contained considerable amounts of included air, which probably accounts for their white appearance. The ice was surprisingly hard and free from any definite cleavage planes. The whitish appearance was generally characteristic of all the bergs met with. In some instances there were narrow streaks of ice, transparent and of a blue color, that penetrated entirely thru the bergs.

The water resulting from the melting of the iceberg was found to have the same density as that of distilled water. It was free from any characteristic taste. So far as our observations go, the temperature of the air furnishes no evidence of value as to the proximity of a berg.

*Discussion of observations.* An examination of the temperature records which were obtained under a variety of conditions, in the region 37° to 43° 30′ north latitude and 43° to 53° west longitude, at once impresses one with the difficulty of separating the large and sudden variations of sea water temperature, so frequently met with, from any variations that may be caused by the proximity of icebergs. We have obtained records in some parts of the ocean in which the temperatures were practically constant to a few tenths of a degree for many hours. On the other hand, some of the records show that the temperature variations in other parts of the ocean, where no ice is near, are as great and as sudden as any observed in the neighborhood of

bergs. Having established the existence of such variations in sea water temperatures, it follows that it will be very difficult and often impossible to draw definite conclusions as to the proximity of ice from temperature records.

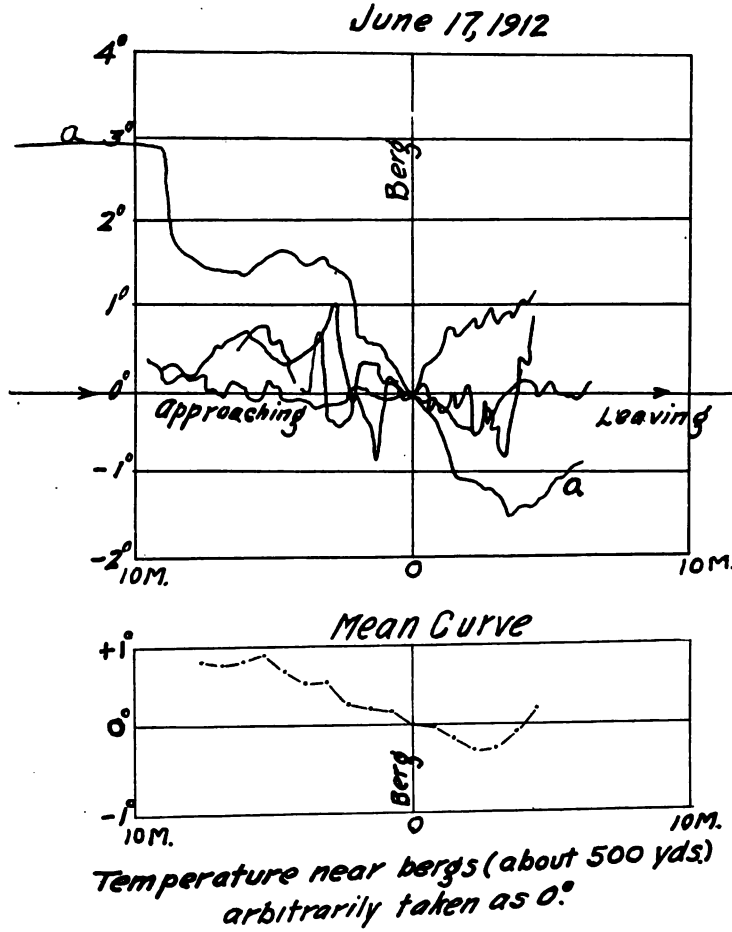


Fig. 2. Temperature about an iceberg

In approaching or leaving a berg the temperature of the sea water may rise or fall or remain practically constant. In figure 2, the temperature records of figure 1 are reproduced, the temperature at the iceberg being arbitrarily taken as the zero of temperatures for each course. Curve a, figure 2, is the temper-

ature record in approaching and leaving a growler. The remainder of the curves in figure 2 are the records for all the courses around the large berg, shown in figure 1. The temperature records for the several courses differ so much that no certain effect can be attributed to the iceberg. The mean of the curves for all the courses is shown in the lower part of figure 2.

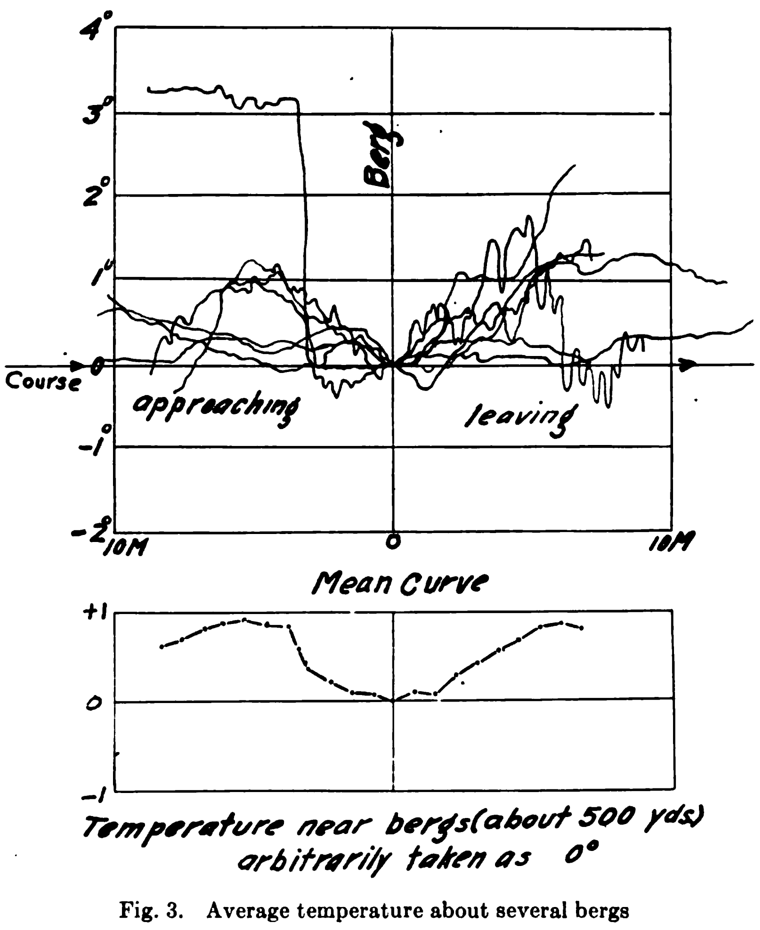


Fig. 3. Average temperature about several bergs

In figure 3 are reproduced all the temperature records, except those of June 17, for approaching and leaving icebergs, the temperatures at the bergs being always arbitrarily taken as the zero of temperature. The mean curve shown below, indicates

that in general there was a fall in temperature of about 1° in 4 or 5 miles in approaching the various bergs. In all but two instances the minimum temperature was found near the bergs. So far as our records go, therefore, it does not seem possible to draw positive conclusions as to the absence or proximity of ice from the temperature records of sea water. This is not a condemnation of the use of suitable recorders on ships. As Barnes has shown, the temperature record may give valuable information on the approach to shore and shallow water, on the identification of characteristic ocean currents, and, as his records seem to show, even of the proximity of icebergs in some parts of the ocean where the variations are less erratic than in the regions in which our observations were made.

If the "characteristic iceberg effect" observed by Barnes, i.e., rise of temperature on approaching icebergs, had been present around the bergs observed by us and of the same or even much less magnitude, our records would have rendered such an effect evident, notwithstanding the irregular variations of temperature usually found to exist. In view of the differences in the character of the records obtained by Barnes and by us, it is very desirable that further observations be made in different parts of the ocean, and under as varied conditions as possible, before attempting to draw final conclusions.

In conclusion, we wish to express our indebtedness to Captain Decker, Captain Hughes, and their officers and crews for their hearty cooperation and many acts of kindness during our stay on shipboard.

ELECTRICITY.—*High-frequency ammeters.* J. H. Dellinger. To appear in the Bulletin of the Bureau of Standards, Scientific Paper No. 206.

For the measurement of current at radiotelegraphic frequencies, about 50,000 to 2,000,000 cycles per second, it is general practice to utilize the thermal effect of the current. The electrodynamic effect of the current has not been very successfully utilized; because, when the wire is coiled up to form an electro-

dynamometer, conditions are favorable (impedance large and capacity large) for part of the current to flow thru the dielectric instead of the wire, in amount varying with the frequency. The superiority of the hot-wire ammeter and the modifications thereof, in high frequency work, is due to the simplicity of form which the portion of the circuit within the instrument may have, permitting a minimum of self-inductance and capacity. A single straight wire of very small diameter is the only form of ammeter circuit which can be taken as *à priori* reliable at all frequencies. When the instrument is required to carry relatively large currents, such a wire is not sufficient, and more than one elementary path must be provided for the current. The distribution of current among these paths is determined solely by the resistances, at low frequencies, while at high frequencies the inductances predominate. Consequently the current distribution and the readings of the instrument are likely to change as the frequency is varied.

There are three general types of ammeters in use for large currents of high frequency: (a) that employing wires in parallel, (b) the so-called unshunted ammeter in which a single wire has different portions of its length in parallel, and (c) the ammeter employing thin metal strips. Both experimental and commercial instruments of all these types were investigated, experimentally and theoretically. All types were found to be subject to errors at radiotelegraphic frequencies. This fact is of great moment, for the ammeter is the cardinal instrument in high frequency work. It is of value in measurements of resistance and power, as well as of current. In some of the ammeters investigated the readings were found to increase with increase of frequency, and in others to decrease. These changes are entirely independent of the thermometric method used to measure heat production. The thermometric device may depend on expansion, calorimetry, electric resistance, or thermoelectric effect.

The observations were made by passing high-frequency and low-frequency current successively thru the instruments. An instrument under test was always in series with an instrument which could be taken as standard, and the two were observed

simultaneously. Thus the ratio of indicated current at high and low frequency, for equal total current in the circuit, was obtained. The high-frequency current was generated by the oscillatory discharge of a condenser across a spark gap. The instruments were in a secondary circuit, loosely coupled to the primary, and consisting of an inductance coil, the instruments, and Leyden jars, in series. The chief source of accidental error in the observations was the slight unsteadiness of the current together with the differing lag of the indicating devices of the instruments.

From the dimensions and arrangement of the wires it was found possible to predict quantitatively the changes of reading of the wire instruments with frequency, while theoretical considerations also made it possible to predict qualitatively the performance of the strip instruments. It is an interesting coincidence that the changes of reading occur just in the range of radiotelegraphic frequencies. In some of the instruments, the current distribution was constant from low frequencies up to about 100,000 then underwent changes, and became constant for 1,500,000 and higher frequencies. Thus, in one sense, physically infinite frequency was practically attained. The order of agreement of calculation and experiment attained with these instruments is in itself one of the most interesting results of the investigation. It shows that calculations based on the formulas for self and mutual inductance of finite portions of a circuit are valid, to the observed degree of accuracy, for short lengths and for damped high-frequency oscillations.

In the case of the parallel wire ammeter, mutual inductances between parts, which had hitherto been supposed to be negligible, are the determining factor in the change of current distribution. In the so-called unshunted ammeter, the errors are chiefly due to the self-inductances of parts other than the hot wire. In this case, they can be minimized by symmetrical location of the current leads. In the strip ammeter, the terminal blocks have been found to be the source of large errors. These are reduced by proper shaping of the blocks.

One effective means of reducing the errors of these ammeters at high frequencies is by using working parts of high resistance,

i.e., metal wires or strips which are very thin and of high resistivity. Another expedient is to change the design so that the deflections depend on the entire heat production in the instrument instead of on that in one branch of its circuit. It was found possible to apply this idea to the thermocouple instruments, as well as to those whose indications depend on other thermometric principles. Still another method of improvement is to arrange the working parts (either wires or strips) as equidistant elements of a cylinder, so that each has the same set of mutual inductances. This design approaches as a limit the circular tube, which theoretically has no change of current distribution with frequency. In common with the others, however, it is subject to an error which has hitherto been overlooked. It is difficult to obtain very thin wires or strips of uniform cross-section, and this variation results in the resistances of elements being unequal while the inductances are substantially equal. As a result the current distribution may be uniform at high frequency and not at low frequency.

Eddy currents induced in neighboring masses of metal are found to cause no error. Inductive action of the leads near an instrument in some cases appreciably affects the readings, and must be guarded against. The distributed capacity of the circuits within the instruments is found to cause no error, but the capacity of auxiliary parts produces an appreciable effect at the highest frequency used, 1,500,000 cycles per second. This effect was very striking, two instruments in series carrying different amounts of current. Apparently part of the current was shunted out of one of the instruments by electrostatic induction. A means of eliminating the effect was found for the purposes of ammeter comparison. This phenomenon suggests that the current in a conducting circuit may not be a definite quantity at frequencies over 1,000,000.

In conclusion, it may be said that all types of ammeters in use for large currents of high frequency are subject to errors. The sources of error have been isolated and studied. Some were shown to be negligible, and others very serious. Means of improving the designs have been worked out.

CHEMISTRY.—*The interpretation of mineral analyses.*[1] ROGER C. WELLS, Geological Survey.

In a recent number of this Journal W. T. Schaller proposed an improvement in the usual method of reducing a mineral analysis to a chemical formula which seems to have some advantages.[2] A little later F. E. Wright and C. E. Van Orstrand published a paper on the determination of the order of agreement between observation and theory in mineral analyses in which they state that Schaller's method is in error in certain details of principle and discuss several methods of making comparisons between analytical data and theoretical formulas based upon the method of least squares.[3] Without doubt both of these papers represent certain advances, but as they stand there is too much variance between them. The subject is one of general interest and fundamental importance so that some further observations may not be inappropriate.

The excellent analysis of pearceite upon which the discussion in these papers is based was published some time ago by F. R. Van Horn and C. W. Cook.[4] At present only methods of comparing the analytical data with theory are in question. Van Horn and Cook obtained from their analysis the atom numbers of sulfur, arsenic and silver 10.80, 2.000 and 7.886 from which they easily deduced the correct formula, $8Ag_2S.As_2S_3$. The real question decided concerned only one atom in 15, that is between the formulas $9Ag_2S.As_2S_3$ and $8Ag_2S.As_2S_3$. The analysis was considerably more accurate than necessary to decide this point.

The improvement proposed in the calculation by Schaller is suggestive altho not essential to the evaluation in this case and consists in the use of an arithmetic mean instead of a single value of the greatest common divisor by which percentages found in an analysis are reduced to numbers of atoms. The details of carrying out this calculation may be found in his paper. He thus obtained the numbers 10.92, 2.02 and 7.97 which are closer to

[1] Published with the permission of the Director of the U. S. Geological Survey.
[2] Journ. Wash. Acad. Sci., **3**: 97. 1913.
[3] Journ. Wash. Acad. Sci., **3**: 223. 1913.
[4] Amer. Journ. Sci., (4) **31**: 518. 1911.

the whole numbers of the formula 11, 2 and 8 than the numbers above. Schaller also expressed the numbers in another form intended to show their variation from whole numbers more clearly as follows $11\times0.993$, $2\times1.01$ and $8\times0.996$. In this form deviations from the requirements of theory are shown as factors of the quantities involved.

Wright and Van Orstrand begin their discussion on page 224 as follows: "The underlying purpose of such calculations is not, however, to improve a chemical analysis by mathematical manipulation, which is obviously impossible, but to obtain a logical basis of comparison for the given analysis with the analysis calculated from the chemical formula." Unfortunately, while objecting to "mathematical manipulation" the authors of the second paper appear to have recommended and rejected methods of calculation on purely mathematical grounds entirely apart from any consideration of the necessary chemical relationships involved.

In the first method of calculation described they begin by inferring that the correct numbers are 11, 2 and 8. They then derive by the method of least squares a "weight percentage composition" (column 5) for comparison with the analysis which totals 99.84. In other words they present a basis of comparison that totals less than the original investigators obtained in their analysis, viz., 99.89, and conclude "the differences between the observed ($y$) and computed ($y'$) values ($o$–$c$, column 1–5) are a proper measure of the degree of approximation of the actual analysis to that computed from the inferred chemical formula." Let us see how this works out. Assuming equal errors in all the percentages of an analysis of the mineral in question, say, 0.10, we come out of the comparison with the following differences: 0.05, 0.09, 0.05 and 0.08. In other words the chemist should have unequal errors in his percentages to obtain a perfect comparison! Now as a matter of fact he does have unequal errors in his percentages, and these errors are roughly proportional to the percentages involved. Working out the scheme on the assumption that the errors are the same fraction, say 1/200th of all the percentages gives no differences whatever. Obviously the more nearly all errors can be made proportional to the quantities of substance involved the better the comparison will turn out on the whole.

This leads us to the conclusion that "residual errors" or "differences" have very little meaning by themselves. This meaning can only be brought out by comparison with the magnitudes involved. For example an error of 1 gram in weighing 7 grams of arsenic is a very different order of error from that of 1 gram in 59 grams of silver. This is a general proposition but it has particular application in chemical operations where we are so frequently concerned with the numbers of atoms involved, the atoms having different weights. If we are to make equally good determinations of atomic quantities of two substances we must keep our *relative* errors not our *absolute* errors the same in the two determinations. So far as my experience in tracing the effects of errors upon the results in different chemical operations goes, I believe that the best policy for the chemist to pursue is to assume a given error in a measurement, carry thru the whole calculation and ascertain exactly what effect the error will produce in the final result. As is well known, relative errors in a magnitude are transmitted unchanged in multiplication and division of the magnitude by other magnitudes, but they are affected irregularly or may practically disappear in additions and subtractions.

The chemist well knows that in addition to "random" errors there are errors that depend on the elements involved and the methods used. For example, it is not difficult to determine silver with accuracy; the same cannot be said of arsenic. Sulfur is usually weighed as barium sulfate, a substance over seven times heavier than its equivalent of sulfur, while copper is frequently weighed as metal. Even if the same accidental error in milligrams is made in weighing these two substances the sulfur determinations will turn out to be seven-fold as accurate as that of the copper. Neglecting these special relations, however, it may be said that *errors will tend to be proportional to the magnitudes involved.* This relation does not hold strictly because the analyst usually allows himself a little more laxity in the case of the minor constituents and in these the "constant" errors attain more significance. *This difference in the nature of the errors is of fundamental importance in deciding upon methods of calculation and comparison.*

In the method employed by Van Horn and Cook one deter-

mination is assumed to be free from error and the remaining atom numbers show discrepancies from the requirement of theory. Schaller's method is a simple method of distributing the discrepancies. It occurred to Wright and Van Orstrand that the method of least squares would give a still better distribution of discrepancies. In the illustration worked out by them, however, (first method) it is obvious that the $y$ values (observed data) are weighted by multiplication by the respective molecular weights ($x$ values). It would be perfectly possible to weight the observation equations in any arbitrary manner. It would seem, however, that if the discrepancies are assumed to be random ones the weighting should be based upon the magnitude of the discrepancies rather than that upon the molecular weights involved. In view of what has been said it can be seen that the weighting should probably also vary with the mineral, the number of atoms, etc., so that the chief difficulty would be in getting chemists to agree upon a system of weighting.

There is some objection from a chemical point of view to any method involving a distribution of discrepancies. It must be borne in mind that a mineral may be a mixture, a solid solution, or a molecular species. All these possibilities occur in nature and some species occur in a state of remarkable purity. Yet it is hardly to be expected that natural products formed from, or open to attack by, migrating solutions of various kinds can be wholly free from inclusions of foreign matter. Under these circumstances a clear differentiation between fact and hypothesis should be preserved. An analysis is a more or less imperfect expression of certain facts, viz., the composition of the substance in question; that this composition may be expressed in a chemical formula is an hypothesis which may find only approximate verification in the case of a mineral. As our knowledge widens minerals are being found more and more to be solid solutions to a slight extent; these interesting relationships are brought out by independent derivations of the atom numbers but masked by a distribution of "errors." Methods involving a distribution of errors are therefore strictly applicable only to very pure compounds.

But in reverting wholly to a comparison of percentages we lose

some advantages possessed by a comparison of the atom numbers. Residuals of the latter may be compared with one another with respect to the possibility of their combination into simple molecules. In objecting to this method of comparison on mathematical grounds the authors of the second paper appear to have overlooked an important distinction. In weighing out the mineral for analysis as well as in all the analytical operations there are the same atoms involved, atoms of different weights—here eleven atoms of sulfur, two of arsenic and eight of silver—so that the percentages of the different elements are already weighed, i.e., "weighted" according to these proportions and, in dividing, the chemist simply tends to restore unit weight to each determination of the common divisor upon which the atomic theory depends. When we compare percentages we compare data for eleven atoms of silver, two of arsenic, and eight of silver; on the other hand, when the comparison is between different values of the greatest common divisor we are comparing numbers having a significance common to all the atoms in the mineral.

Now in view of the consideration on page 419 it appears in general that (a) when percentages are compared the principal constituents will contain the smallest relative errors while constant errors will tend to compensate one another. The total essential constituents expanded to 100 per cent will therefore be the best basis of comparison with the theoretical percentages. (b) When the atom numbers are to be compared the one obtained from the minor constituent will be most affected by "constant errors" such as those of weighing and measuring, the one obtained from the major constituent will be most affected by "relative errors," those proceeding from chemical transformations. Which kind of error will predominate here will depend again upon the mineral and the method of analysis. The plan has heretofore been to base the value of the common divisor upon the minor constituent. Schaller's proposal bases the divisor upon all the constituents. Another plan would be to base the value of the common divisor upon the chief constituent or the most accurately determined one. A factor may be *very simply obtained*, however, *by taking 1/100th of the molecular weight assumed for the mineral,*

which is obviously theoretically correct for each formula assumed.[5] It is then only necessary to multiply the combining ratios found, by this factor, to obtain the exact atom numbers found in the analysis.

The comparison of the analysis under discussion with theory may therefore be made by either of the two following methods:

FIRST METHOD

| | PERCENTAGES FOUND | EXPANDED TO 100 PER CENT | THEORY FOR $8Ag_2S.As_2S_3$ | ABSOLUTE DISCREPANCY | RELATIVE DISCREPANCY IN PER CENT |
|---|---|---|---|---|---|
| S.......... | 17.46 | 17.48 | 17.56 | −0.08 | −0.5 |
| As......... | 7.56 | 7.57 | 7.46 | +0.11 | +1.5 |
| Ag........ | 59.22 | 59.28 | 59.32[1] | −0.04 | −0.1 |
| Cu........ | 15.65 | 15.67 | 15.66 | +0.01 | +0.1 |
| | 99.89 | 100.00 | 100.00 | Mean ±0.06 | Mean ±0.5 |

SECOND METHOD

| | COMBINING RATIOS FOUND[2] | ATOM NUMBERS FOUND[4] | THEORY | ABSOLUTE DISCREPANCY | RELATIVE DISCREPANCY IN PER CENT |
|---|---|---|---|---|---|
| S.......... | 0.5451 | 10.95 | 11.00 | −0.05 | −0.5 |
| As......... | 0.1010 | 2.029 | 2.000 | +0.029 | +1.5 |
| Ag[3]........ | 0.2748 | | | | |
| Cu[3]........ | 0.1233 | 8.000 | 8.000 | 0.000 | 0.0 |
| | | | | Mean ±0.02 | Mean ±0.5 |

[1] Calculated from the combining ratios as follows: $16\times\left(\frac{0.2748}{0.3981}\right)\times 107.88$. Similarly for the copper. In the case of replacements such as that of copper for silver here the molecular weight assumed must be obtained by taking proper proportions of the atom numbers of the simplified formula. As the number of replacements increases, the more difficult it becomes to derive either a "theoretical" molecular weight or a theoretical percentage.

[2] Obtained from 17.48, etc., above by dividing by atomic weights.

[3] Considered as $Ag_2$ and $Cu_2$.

[4] Obtained from 0.5451, etc., by multiplying by $\left(\frac{2009.1}{100}\right)$ where 2009.1 is the molecular weight assumed.

[5] If $M$ is the molecular weight assumed 1 per cent of $M$ is $\frac{M}{100}$; if $y$ per cent of an element has been found, the molecular portion will be $\frac{yM}{100}$ and this will be as many atoms as the atomic weight of that element is contained in $\frac{yM}{100}$ or $\frac{yM}{100A}$; hence the factor for each molecular ratio will be $\frac{M}{100}$.

If the arguments set forth in the preceding discussion are valid the relative discrepancies in the last columns are the best indices of the agreement of the data found with the formula assumed. To say that 10.95 has a discrepancy of $-0.5$ per cent from the theoretical value 11 is very similar to expressing 10.95 as $11. \times 0.995$. In my opinion the "mean relative discrepancy" is probably the best single value which can be found to indicate the order of agreement of a mineral analysis with the formula.

The principal conclusions in this paper may be summarized as follows:

1. "Differences" are not a good measure of concordance when comparisons are made between several numbers of different magnitude or where different chemical elements are concerned. The discrepancies should also be thought of as factors or percentages of the quantities involved.

2. Before a mathematical simplification in analytical data is attempted the nature of possible errors and their mode of transmission to the final result should be considered.

3. The analytical percentages of a mineral analysis will in general contain some random errors and will certainly contain errors characteristic of the individual elements. The errors will however tend to be proportional to the quantities of substance involved. If the chemist wishes to bring up the accuracy of all the constituents to their full measure in the determination of the whole mineral, he should devote his chief attention first to the constituent which he believes to be subject to the greatest absolute error and next to the other constituents in the order in which they occur by weight beginning with the predominating one.

4. Any method of comparing the analytical data with theory which involves a distribution of the discrepancies may mask some relations, such as those of solid solution or the presence of a free element and should therefore be used only in the case of pure compounds.

5. The percentage of the essential constituents found should first be expanded to 100 per cent and then compared directly with the theoretical percentages. Or the combining ratios found may be multiplied by the factor $\frac{\text{molecular weight assumed}}{100}$ and the atom numbers thus found compared with theory.

6. The "mean relative discrepancy" of all the determinations is probably the best single index of the agreement of a mineral analysis with a chemical formula.

CHEMISTRY.—*Note on the analysis of water from a deep well in Pennsylvania.* GEORGE STEIGER, Geological Survey.

The well from which the water was obtained is situated eight miles southwest of Imperial, Allegheny County, and five miles northwest of McDonald, Washington County, Pennsylvania.[1] Down to 6300 feet the well was perfectly dry; at this point water was encountered and finally filled the well to a depth of 3000 feet.

At the request of Dr. G. F. Becker, the Peoples Gas Company, owners of the well, collected two samples of five gallons each. One sample was sent to the laboratory of the Bureau of Mines at Denver for radioactive tests; the other was shipped to the laboratory of the U. S. Geological Survey for the general chemical analysis.

GRAMS PER KILOGRAM OF WATER

| | | | |
|---|---|---|---|
| Fe | 0.16 | $SO_4$ | 0.05 |
| Mg | 2.48 | Cl | 161.80 |
| Ca | 25.19 | Br | 0.70 |
| Sr | 3.55* | I | |
| Ba | trace | | |
| Na | 64.55 | | 263.64 |
| K | 5.16 | Sp. G. | 1.211 |

$112.5 \times 10^{-11}$ grams of radium per liter.

Silicon, aluminum, titanium, phosphorus, manganese, lead, bismuth, and carbonic acid, were tested for and were found to be absent.

* Equivalent to 7.8 grams of $SrCl_2$ per liter.

This water contains about eight times the quantity of dissolved salts per kilogram as that of sea-water. When received, a quantity of suspended matter was present, probably finely divided rock introduced through the process of drilling. This was separated by filtration and the filtrate which was perfectly clear was used for analysis. Dr. Becker who will be assisted by Mr. C. E. Van Orstrand, in the near future, intends studying the well regarding temperature and radioactivity. It was in rela-

[1] A complete description of this well by I. C. White will be found in the Bulletin of the Geological Society of America, **24**: 273-282. 1913.

tion to the radioactivity that lead, bismuth, and barium were very carefully tested for.

When time permits drill cores of the accompanying rock will be analyzed in the hope of throwing some light on the source of the large strontium content; this metal being of rare occurrence in surface rocks of this locality. Dr. R. B. Moore who kindly made the determination of the radioactive matter states that the amount is not excessive for water of this character.

For the collection of the water the Survey is indebted to Mr. John G. Pew, Vice-President of the Company.

BOTANY.—*A new shrubby buckeye.* W. W. Ashe, Forest Service.

*Aesculus microcarpa* sp. nov. Leaves with slender glabrous petioles, much longer than the middle leaflet; mostly five obovate-oblong leaflets, which are sharply serrate, slender petiolulate, glabrous on unfolding except for minute tufts of hair in the axils of the veins; when mature glabrous, firm in texture and pale beneath; twigs slender, glabrous, glaucescent. Flowers, opening in Rabun County, Georgia, the last of April and early in May, about 3 cm. long, pale yellow or toward base orange, petals connivent, very unequal, puberulent, the claws puberulent; claws of lateral pair longer than calyx tube, the limb ovate or oblong; pedicels slender, mostly longer than the oblong-campanulate puberulent calyx tube. Fruit smooth, about 3 cm. thick, one-seeded, with thin, smooth reddish brown valves; seed spheroid, about 2 cm. in diameter. A shrub 1 to 3 m. in height. Growing with *Aesculus pavia* L. along rocky banks of streams and open red clay hills of western South Carolina and northern Georgia, between altitudes of 160 and 500 m. Type material which is in the herbarium of the author, is from Cherchero Creek, Rabun County, Georgia; it was collected in April and September, 1911.

This shrub is most closely related to *Aesculus octandra* Marsh, which grows with it along the upper edge of its distribution in Rabun County, Georgia. The flowers of the proposed species are about one-third larger than those of *Ae. octandra*, more slender, not so pubescent, the calyx more tubular, and the thyrse is smaller. The seed is solitary, spheroid, and about one-half the size of that of *Ae. octandra*.

# ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*The determination of aqueous vapor above Mount Wilson.* F. E. Fowle. Astrophysical Journal, **36**: 359. 1913.

The quantity of precipitable water existing in the form of vapor between the top of Mount Wilson and the outer limits of our atmosphere during fair weather from June to November, 1910, and 1911, was determined by the spectrobolometric method described in detail in the Astrophysical Journal, **35**: 149. 1912 (see this journal, **2**: 318. 1912). The average quantity present was 0.69 cm. and the range from 0.2 cm. to about 2.8 cm. of precipitable water. The difference in the monthly means would be small but for a few exceptionally moist days in August; almost the dryest day indeed for 1910 was August 13 (0.17 cm.) and the dryest for 1911, September 12 (0.12 cm.). A gradual but generally slow increase in atmospheric water vapor often took place during the observations which extended from about 7 a.m. to 10 a.m. This averaged 0.12 cm. For about 40 per cent of the days this increase was less than 0.1 cm.

These spectrobolometric results were then used in a study of the formula of Hann which, with a coefficient determined from balloon and kite observations, has been in use for connecting surface humidities with the quantity of aqueous vapor in the atmosphere. This coefficient was redetermined by means of the data above discussed. The general mean for the coefficients (1.8) agrees closely with that derived by Hann (1.9), also with that from Humphrey's data (1.7). The range of values is, however, so great (from 0.33 to 11.80) that we must regard the formula, though applicable for mean conditions, as of no value for individual days. F. E. F.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 724th meeting was held on April 12, 1913, at the Cosmos Club. President Abbot in the chair; 55 persons present. The minutes of the 723d meeting were read and approved.

Mr. R. S. Woodward presented a paper on *The laws of falling bodies.* The history of the subject, beginning with the first consideration of the problem by Gauss and Laplace 110 years ago, was reviewed. These investigators differed in their conclusions, Gauss maintaining that there is a meridional deviation towards the equator, which Laplace denied. Poisson made some corrections to Gauss's work but accepted his conclusions, as did most of the subsequent workers. In view of conflicting opinions, differences in experiments, and of obvious defects in the memoirs, the speaker has thought it worth while to study the subject further, taking into account the recent work in geodesy. The method of Lagrange was used to derive the equations. The height of fall was limited so that there would be no exterior effects on account of other bodies. Discussion of equations was carried to terms of the second order and some results of the application of the formulae given. The conclusion reached was that the deviation in the meridional plane due to the rotations and figure of the Earth is towards the north. The easterly deviation is very much larger than the northerly. There is need of more information regarding the geodesy of the subject. The paper was discussed by Messrs. Bauer, Littlehales, Wead, and Rosa.

Mr. C. W. Waidner spoke on *Sea water temperatures in the vicinity of icebergs,* giving results of the experiments carried out by a party of three from the Bureau of Standards on a United States cruiser. The thermometer was a flat rectangular nickel coil enclosed between two copper plates pressed close to the side of the ship and connected to a Leeds and Northrup recorder. The equipment and charts showing some of the records were illustrated by lantern slides. So far as detection of proximity of icebergs is concerned, the general conclusion was that, while such records may be of help, the normal variations are generally so erratic and large in comparison with effect due to icebergs that it is practically impossible to get definite indications from the records. Other experiments made on salinity and density of sea water indicated that nothing could be accomplished, as the diluting effect is infinitesimal. The paper was discussed by Messrs. Bauer, Littlehales, and Burrows as to the radiation method from the surface of icebergs and by Mr. Abbot.

J. A. Fleming, *Secretary.*

## THE BIOLOGICAL SOCIETY OF WASHINGTON

The 512th meeting of the Biological Society of Washington was held on April 19, 1913 at the Cosmos Club, with Vice-President Hay in the chair and about 30 persons present.

HENRY TALBOTT exhibited an unusually large tooth of the fossil shark, *Carcharodon megelodon* from South Carolina and by way of comparison the much smaller teeth of Odontaspes from Chesapeake Beach, Maryland.

WELLS W. COOKE commented on the spring migration of birds, noting that this year the yellowthroat, redstart, wood thrush and catbird had arrived three days ahead of schedule time.

The regular program consisted of a communication by C. D. MARSH, on *Stock Poisoning by Larkspur.* He stated that ranchmen of the west had long claimed losses of stock due to larkspur, and on scientific inquiry had found their observations correct, and that the monetary loss was considerable. Altho larkspur occurs in other parts of the world it apparently only causes trouble in the Western United States. The average mortality in affected areas of the west is from 3 to 5 per cent, but as many as 20 head out of a herd of 200 have been fatally poisoned in twenty-four hours. The low larkspur appears to be always dangerous, but the tall only becomes so in August after the fruit matures. The poison is a cumulative one and requires from 3 to 10 per cent of the animal's body weight of larkspur plant to cause death or alarming symptoms. The symptoms consist of general discomfort, nausea, constipation, a characteristic arching of the back and sudden collapse, followed by partial recovery and a repetition of similar attacks, and if the case is a fatal one, to end in respiratory paralysis and death by asphyxia. Animals do not become immune to the poison. Horses may be experimentally poisoned but when feeding on the range do not eat into a patch of larkspur enough to consume a toxic quantity. Sheep are naturally immune to the poison and may be fed a continuous diet of little else than larkspur without showing any symptoms. The cowboy's treatment of the disease is bleeding but the proportion of recoveries by this method is not greater than in natural recovery. Rational treatment consists in placing the poisoned animal on sloping ground with head upward so that the abdominal viscera fall back from the thoracic organs. Drug treatment consists of eserin pilocarpine and strychnine administered hypodermically. Under this method 96 per cent of poisoned animals recover. Alcohol is also effective but less practical. The paper was illustrated by lantern slides, showing the larkspur in detail and on ranges, and numerous animals in various stages of poisoning. The paper was discussed by Messrs. Bailey, Weed, Hitchcock, Gill, Lyon and others.

The 513th regular meeting of the Biological Society of Washington was held on May 3, 1913 at the Cosmos Club, with President Nelson in the chair and 56 persons present.

Dr. H. M. Smith called attention to a large whale shark captured during the past year in Florida waters. It originally measured 38 feet in length, but as now mounted, 45 feet. Pictures of this shark were exhibited and extracts from a letter by the captor read. Dr. Smith's remarks were discussed by the chair and by Dr. Gill.

REGULAR PROGRAM

*The remarkable extinct fauna of southern California revealed in the asphalt deposits near Los Angeles*: Dr. C. Hart Merriam.

The asphalt in this region was known to the Indians for centuries and was mentioned by the early Spanish padres. Altho remains of animals in the asphalt deposits have been known since about the middle of the last century, they have only lately been extensively studied by Dr. J. C. Merriam of the University of California. The viscous asphalt appears to have acted as a natural trap, first entangling certain birds and mammals, which in turn served as bait to larger predatory forms. The remains may be roughly divided into three groups: (1) Birds, some still existing, but mostly extinct, among them, hawks, eight genera of eagles, vultures, including both North and South American condors, a condorlike bird, *Teratornis* of huge size, owls, ravens, herons, a peacock; (2) Small mammals, as spermophiles, kangaroorats, etc., and small carnivorous forms as weasels, skunks, badgers, bobcats, grey foxes; (3) Large mammals, as deer, antelopes, buffaloes, elephants, mastodons, glyptodons, and large predatory forms as wolves, mountain lions giant lions, sabertoothed tigers, and bears. Often several individuals of carnivorous forms, as giant wolves, sabertoothed tigers are associated with a single large ruminant. Discussed by Messrs. Gill, Hay and others.

*Notes on the big bears of North America:* Dr. C. Hart Merriam. The speaker commented on the lack of adequate material for a systematic study of these bears. The black bear and allied forms he regarded as constituting a distinct genus from the brown and grizzly bears belonging to the genus Ursus, about forty forms of which could be recognized as inhabiting the North American continent and adjacent islands.

*Distribution of game animals in Africa:* Edmund Heller. Mr. Heller spoke of the life zones and areas of East Africa illustrating the subject with maps, views of topography, and characteristic mammals. The following areas, based mainly upon watersheds, were recognized: West Nile, East Nile, Uganda, East Africa, Abyssinia; and these life zones: Congo Forest, Tropical, Nyika, Highland Veldt, Highland Forest.

M. W. Lyon, Jr., *Recording Secretary, pro tem.*

## THE PROCEEDINGS

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PETROLOGY.—*Magnetite basalt from North Park, Colorado.*[1] H. S. WASHINGTON and E. S. LARSEN. Geophysical Laboratory and Geological Survey.

The rock described in this paper was collected by A. L. Beekley of the United States Geological Survey, to whom the authors are indebted for the material and for the description of its occurrence. The specimen was collected at the top of Pole Mountain in North Park, Colorado, about three miles southwest of Coalmont. The summit of Pole Mountain is a small remnant of the Tertiary volcanic rocks which are extensively developed on the higher slopes to the south. The outcrops are poor and the material probably represents a breccia. Most of the neighboring Tertiary volcanic rocks are basaltic; but they are rich in soda and in them magnetite is not exceptionally high.

The magnetite basalt is black, aphanitic and very porous; megascopically it shows no determinable crystals. The microscope shows that it is holocrystalline, and is made up of about one-half magnetite, with nearly equal amounts of bytownite and pale green augitic pyroxene, and a smaller amount of apatite. The texture is poikilitic; euhedral crystals of magnetite are rather evenly included in anhedrons of both feldspar and pyroxene. The rock is apparently perfectly fresh. On account of the porosity no determination of the specific gravity was made.

A chemical analysis was made, using the standard methods. All of the major constituents, (except the alkalies,) and also titanium were determined in duplicate, with closely agreeing

[1] Published by permission of the Director of the U. S. Geological Survey.

ANALYSES OF IRON ORE IGNEOUS ROCKS

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 19.74 | 21.42 | 17.90 | 11.73 | 26.62 | 20.30 | 10.77 | 7.82 | 4.08 | 8.04 |
| $Al_2O_3$ | 9.72 | 7.03 | 10.23 | 6.46 | 11.62 | 7.60 | 4.61 | 3.20 | 6.40 | 0.39 |
| $Fe_2O_3$ | 39.70 | 30.34 | 15.85 | 30.68 | 19.50 | 29.99 | 39.27 | 29.40 | 33.43 | 88.41 |
| FeO | 15.60 | 22.81 | 27.95 | 27.92 | 21.87 | 25.65 | 21.73 | 29.78 | 34.58 | 2.52 |
| MgO | 3.70 | 6.92 | 6.04 | 3.35 | 2.57 | 3.68 | 2.34 | 5.67 | 3.89 | 0.06 |
| CaO | 6.64 | 3.59 | 2.86 | 3.95 | 6.47 | 3.50 | 4.84 | 3.42 | 0.65 | 0.23 |
| $Na_2O$ | 0.46 | 0.53 | | 0.50 | 1.06 | | 0.31 | 0.61 | 0.29 | 0.05 |
| $K_2O$ | 0.66 | 0.41 | | 0.26 | 0.34 | | 0.24 | 0.17 | 0.15 | 0.29 |
| $H_2O+$ | 0.32 | 0.95 | 1.33 | 0.64 | 1.30 | 1.70 | 0.44 | 0.38 | 1.32 | 0.17 |
| $H_2O-$ | 0.04 | | | | | | | | | |
| $CO_2$ | none | tr. | 0.10 | 0.32 | | | | | | |
| $TiO_2$ | 0.58 | 5.21 | 15.66 | 12.31 | 9.50 | 7.80 | 13.52 | 17.23 | 14.25 | 0.39 |
| $P_2O_5$ | 1.67 | 0.14 | 0.04 | 0.82 | | 0.03 | 0.02 | 0.14 | 0.02 | tr. |
| Cl | | 0.42 | | 0.12 | | | | | | |
| S | | 0.04 | 0.14 | 0.04 | | 0.10[2] | 0.11 | 0.06 | | 0.02 |
| $Cr_2O_3$ | none | none | 0.51 | | | | | | 0.20 | |
| $V_2O_3$ | 0.44 | | 0.55 | 0.04 | | | 0.52 | 0.63 | | |
| MnO | 0.38 | tr. | tr. | | 0.20 | 0.34 | 0.37 | 0.22 | 0.45 | 0.02 |
| NiO | none | | | | | | 0.27 | 0.43 | | |
| CoO | | | | | | | 0.07 | 0.10 | | |
| BaO | | | | | | | 0.07 | | | |
| | 99.75 | 99.81 | 99.15 | 99.19[1] | 101.05 | 100.69 | 99.50 | 99.26 | 99.71 | 100.59 |

[1] Including 0.05 C.
[2] $SO_3$

A. Magnetite basalt (Arapahite). Pole Mountain, North Park, Colorado. H. S. Washington, analyst.

B. Iron ore. Elizabethtown, Essex County, New York. W. F. Hillebrand analyst. J. F. Kemp, 19th Ann. Rep. U. S. G. S., **3**: 408. 1899.

C. Iron ore. Westport, Essex County, New York. W. F. Hillebrand, analyst. J. F. Kemp, loc. cit., p. 402.

D. Iron ore. Lincoln Pond, Essex County, New York. W. F. Hillebrand, analyst. J. F. Kemp, loc. cit., p. 407.

E. Magnetite rock. Joubrechkine, Wichera, North Ural Mountains. Duparc (?), analyst. Duparc and Pearce, Mem. Soc. Phys. Gen., **36**: 187. 1909.

F. Magnetite rock. Joubrechkine, Wichera, North Ural Mountains. Duparc (?), analyst. Duparc and Pearce, loc. cit., p. 187.

G. Iron ore. Pine Lake, Victoria County, Ontario. F. J. Pope, analyst. F. J. Pope, Trans. Amer. Inst. Min. Eng., **29**: 380. 1899.

H. Iron ore. Horton, Renfrew County, Ontario. F. J. Pope, analyst. F. J. Pope, loc. cit., p. 380.

I. Magnetite spinellite. Routivaara, Sweden. W. Petersson, analyst. W. Petersson, Geol. För. Förh., **15**: 49. 1893.

J. Iron ore. Kiruna, Lapland. G. Nyblom, analyst. P. Geijer, Geol. Kiruna Distr., 1910, p. 177.

results. Titanium was determined (in duplicate) by the colorimetric method, as its amount was small, the color effect of the very large amount of iron being removed by the addition of phosphoric acid, a corresponding amount being added to the standard manganese solution.[2] In a special large portion nickel, chromium and vanadium were tested for. Not a trace of nickel was found with dimethylglyoxime as a reagent. A coloration, possibly due to chromium, was barely perceptible, even when the solution was highly concentrated, and the amount of this cannot be as much as 0.01 per cent, even if present. Vanadium was determined by Hillebrand's method and its presence was verified after the titration. Combined water was determined by Penfield's method. The amount of $V_2O_5$ was subtracted from that of $P_2O_5$, as it is precipitated and weighed with the phosphomolybdate,[3] if the latter is in sufficient excess. This is a point to be borne in mind in the analysis of rocks containing notable amounts of vanadium.

The analysis shows some remarkable features and, while nearly all its constituents can be matched in the other analyses of iron ore rocks derived from igneous magmas, it does not correspond in all respects with any of them. One of the Adirondack ores (B) resembles it most closely. It is especially remarkable in the very low titanium, the hematite ore of Kiruna alone approaching it in this respect. The phosphorus is notably higher than elsewhere, while the absence of nickel and chromium is noteworthy. The amount of vanadium is about that of most of the Adirondack and Ontario ores.

The norm of the Colorado basalt is as follows:

| | | | |
|---|---|---|---|
| Or | 3.89 | Mt | 49.88 |
| Ab | 3.67 | Il | 1.06 |
| An | 22.24 | Hm | 5.28 |
| C | 0.10 | Ap | 4.03 |
| Hy | 7.70 | | |
| Ol | 1.12 | | 98.97 |
| | | Rest | 0.80 |
| | | | 99.77 |

[2] Cf. W. F. Hillebrand, Bull. 422, U. S. G. S., 1910, p. 134.

[3] Cf. J. R. Cain and J. C. Hostetter, Techn. Pap. Bur. Stand., No. 8, 1912.

This places it in the dofemane class and in the domitic order (adirondackore), but transitional to the permitic order, hypersthene and olivine being very low. It is in the permiric rang and perhemic subrang—a position which is briefly expressed by the symbol IV.4(5).1.1. The rang and subrang are as yet unrepresented and unnamed. The North Park District was occupied by the Ute and Arapaho Indians, according to information furnished by Mr. W. Marr of Hebron, Colorado. As the use of the name Ute would suggest a locality in Utah, it seems to be preferable to name the rang *arapahase* and the subrang *arapahose.*

The mode of the rock can be approximately estimated from the norm, the corundum, hypersthene, olivine and a little anorthite being assumed to enter the pyroxene. The mode would then be about as follows:

| | |
|---|---|
| Bytownite | 25 |
| Augite | 15 |
| Iron ores | 56 |
| Apatite | 4 |

The mode is, therefore, practically normative. As remarked by Iddings[4] this is "at present the only known example of extruded lava corresponding to the segregated iron ores." It may be pointed out that nearly all such other iron ore rocks are associated with gabbros, those of Kiruna (which are of hematite) being derived from syenites, according to Geijer, and those of Brazil (of which there are no analyses available) being associated with highly sodic, nephelite-rich rocks. The relations of the Colorado rock are too little known as yet for any discussion of its associations.

While the rock would logically be called a magnetite basalt, on account of its extrusive character and mode, yet it is so unique as to occurrence and chemical composition, that a special name seems to be justified. For this that of *arapahite* is suggested.

[4] J. P. Iddings, Igneous Rocks, **2**: 332. 1913.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

PHYSICS.—*Latent heat of fusion of ice.* H. C. Dickinson, D. R. Harper, and N. S. Osborne. Bulletin, Bureau of Standards. In Press.

Of the two experimental methods employed, one is the well known method of mixtures in which an ice sample of from 100 to 200 grams weight was allowed to melt in the calorimeter, cooling the water. The other was an electrical method of somewhat higher precision. An ice sample 500 grams in weight was put directly into the water and the approximate amount of energy required to melt the ice supplied electrically and measured, the small excess or deficiency being determined from the small rise or fall of temperature of the calorimeter. The usual calorimetric cooling correction was thus rendered relatively very small and the heat capacity of the calorimeter needed to be known only approximately. The ice specimens used were from commercial plate, can, and natural ice, and from ice frozen in the laboratory from double distilled water both free from air, and containing air. They were cut in the form of hollow cylinders to secure a more uniform rate of melting. The samples were kept at the uniform temperature of either $-0^{\circ}.72$ or $-3^{\circ}.78$ for several hours previous to the experiments, and were so weighed and handled as to introduce each into the calorimeter at the selected constant temperature with no significant error. The heat of fusion of each of 92 samples of pure ice was determined by one of the two methods. The results of the first half of these observations, made before the best experimental conditions were secured, indicate no differences between the heats of fusion of the different kinds of ice greater than the limits of precision, that is, about one part in a thousand. The latter half show no difference as great as one part in five thousand between the commercial kinds of ice. The final figure for the heat of fusion of pure ice is 79.63 $cal_{15}$ per gram mass.

H. C. D.

GEOLOGY.—*The enrichment of sulfide ores.* W. H. EMMONS. Bulletin U. S. Geological Survey No. 529, pp. 252. 1913.

The theory of sulfide enrichment is stated as follows:

> No metallic sulfide that is long exposed to air and water remains unaltered. Iron sulfides, which are present in practically all sulfide ores, are changed by weathering to iron oxides, and the changes are attended by the liberation of sulfuric acid. Many of the metals form soluble sulfates with sulfuric acid, and when conditions favor their migration downward they are carried in solution to depths where air is excluded. Unoxidized rocks are in general alkaline. Acid solutions that encounter such rocks in the regions where air is excluded will lose acidity, and as the solutions approach a neutral or alkaline condition some of the metals they contain are deposited. If the solutions of the metallic sulfates encounter metallic sulfides in depth precipitation may take place, or there may be an interchange between the metals in solution as sulfates and the metallic sulfides. Thus as a result of precipitation or chemical interchange the metals are redeposited and certain portions of the ore bodies become enriched.

The effects of physical conditions on the process of enrichment are discussed and the chemistry of the process is approached from both the experimental and the theoretical side, the chemical relations of minerals of copper, silver, gold, lead, zinc, and iron being discussed in turn.

The literature of the principal deposits of copper, gold, and silver sulfide ores in North America is reviewed with special reference to the extent, character, and distribution of the secondary ores in each. Of copper deposits with deeply enriched zones none are known to carry pyrrhotite or abundant sphalerite. The data indicate that, in general, ores containing abundant pyrrhotite and sphalerite become more thoroly oxidized than those containing pyrite and chalcopyrite without pyrrhotite or sphalerite; but oxidation and enrichment are not likely to extend as deep in pyrrhotite or sphalerite ores.

Many auriferous deposits in the surficial zone appear not to have been enriched by secondary agencies, while in others there is no evidence of solution and re-precipitation of gold. It is concluded that the solution of gold depends in the main on the presence, simultaneously, of manganese and chlorides. Its migration depends on the permeability of the lodes and the material of the primary ores. Of the common minerals calcite and pyrrhotite will probably precipitate gold from auriferous solutions most rapidly. All the districts of silver-gold deposits in which gold is assumed to have migrated include manganiferous ores. In deposits carrying both metals, especially where chlor-

ides form, secondary silver minerals are likely to be precipitated as bonanzas near the surface, while gold may be carried to greater depths. Abundant pyrrhotite in the primary ore quickly halts the downward migration of both silver and gold. SIDNEY PAIGE.

GEOLOGY.—*Kenova, Ky., West Virginia and Ohio, folio.* W. C. PHALEN. Geologic Atlas of the United States, Folio 184, page 16; with maps and sections, U. S. Geological Survey. 1912.

The rocks exposed include both the igneous and sedimentary classes. The igneous rocks are peridotite dikes which cover a small area in the western part of the quadrangle and are of interest in having been prospected for diamonds. The sedimentary rocks belong in the Carboniferous and Quaternary systems. The former system includes both the Mississippian and Pennsylvanian series. Included in the Mississippian are the Logan Formation and the Maxville Limestone. In the Pennsylvanian are included the Pottsville, Allegheny, Conemaugh and Monongahela formations. Pleistocene and Recent deposits constitute the Quaternary system.

Tho no part of the quadrangle lies within the glaciated region, it contains deposits of Pleistocene age. These are the low and high level river gravels along the Ohio and Big Sandy Rivers and back of the city of Ashland, in a district known as the "Flatwoods." They were formed by rivers that abandoned their former courses as a result of the invasion of the neighboring region by ice.

The asymmetry of the drainage is probably dependent both on present structure and the character of the rocks which are mainly sandstones, sandy shales and shales. Excepting the shales, the rocks are water-bearing and produce many springs. The underground currents flow more readily with the dip than against it, with the consequent tendency for erosion, both surficial and possibly underground to proceed up the dip. Thus the main streams of the region tend to lengthen those tributaries, which, flowing with the dip, erode more rapidly than those flowing against it, and consequently to push the divides between trunk streams westward on the west side of the synclinal axis and eastward on the east side of this axis. W. C. P.

BOTANY.—*A key to common Nebraska shrubs.* William H. Lamb, Forest Service. Forest Club Annual, University of Nebraska **5**. 1913.

This is a key, based on prominent distinctive characteristics that can readily be observed by those who have had no special training in botany, and intended as a guide in the identification of the more common genera of shrubs and woody vines native and original in Nebraska. W. H. L.

ZOOLOGY.—*Descriptions of twenty new recent unstalked crinoids, belonging to the families Antedonidæ and Atelecrinidæ, from the Dutch East Indies.* Austin H. Clark. Notes from the Leyden Museum, **34**: No. 2, Note XXV. 1912.

The following new species, all collected by the Dutch steamer *Siboga* in the Dutch East Indies, are herein described: *Antedon moluccana, Compsometra iris, Compsometra parviflora, Compsometra longicirra, Compsometra gracilipes, Iridometra (Eumetra) aphrodite, Iridometra gracilis, Toxometra purpurea, Psathyrometra major, Psathyrometra minima, Psathyrometra inusitata, Psathyrometra anomala, Nanometra clymene, Trichometra delicata, Trichometra brevipes, Thaumatometra alcyon, Thaumatometra thysbe, Atopcrinus* (a new genus of Atelecrinidæ) *sibogæ, Atelecrinus sulcatus* and *Atelecrinus anomalus.* A. H. C.

ENTOMOLOGY.—*Piccole note su degli Onychophora.* Austin H. Clark. Zoologischer Anzeiger, **42**: 253–255. 1913.

Thru the courtesy of President J. C. Branner of Stanford University, California, and of Prof. J. H. Comstock of Cornell University, Ithaca, New York, the author has been enabled to examine a specimen of *Peripatus* taken by President Branner at Breves, on the island of Marajó at the mouth of the Amazons, in 1882 and recorded by him, under the generic name only, in 1886. It proves to be an example of *Peripatus (Epiperipatus) simoni* Bouvier.

A specimen received thru Mr. W. E. Broadway from Tobago, British West Indies (a new locality for the group) represents *Peripatus (Epiperipatus) trinidadensis* Stuhlmann, but appears possibly to indicate a local variety, for which the name *Peripatus (Epiperipatus) broadwayi* is suggested.

A specimen of *Peripatus (Peripatus) juanensis* Bouvier is recorded from Vieques, near Porto Rico, and three specimens of *Peripatoides novae-zealandiae* (Hutton) are recorded from New Zealand. A. H. C.

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# JOURNAL

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GEOPHYSICS.—*Water and the magmatic gases.* ARTHUR L. DAY and E. S. SHEPHERD. Geophysical Laboratory.

Two serious attempts have been made in recent years to establish a conclusion which geologists generally have been somewhat slow to accept, namely, that water of magmatic origin is not found among the gases exhaled by active volcanoes.[1] Notwithstanding the fact that this conclusion is diametrically opposed to the commonly accepted explanations of volcanic activity and the further fact that the evidence offered in both instances is of a somewhat fortuitous kind, it has hitherto remained uncontroverted by well-established facts of observation. It may therefore have some interest to present very briefly the preliminary results of a study of the volcanic gases emanating from the Kilauea crater during the summer of 1912 the ultimate purpose of which is to endeavor to establish the character and effects of the chemical reactions concerned in volcanic activity. It happens that both of the attempts to show that volcanic emanations are anhydrous have depended chiefly upon evidence obtained at this crater.

The character of the evidence hitherto offered may be illustrated briefly as follows. Green noted that active lava flows, and even the Kilauea crater itself, often appear to be giving off gases in quantity when no steam cloud can be seen above them. Brun observed that the cloud when present does not evaporate in the air and shows no optical phenomena in sunlight. He was able to obtain no condensed moisture in glass tubes exposed within

[1] William Lowthian Green, Vestiges of the molten globe, vol. 2. 1887. Albert Brun, Recherches sur l'Exhalaison Volcanique. 1911.

the smoke cloud (100 meters distant from the point of emergence), and he observed further that a dew-point hygrometer exposed within the cloud indicated a smaller moisture content than in the clear air near-by. Some other observations were offered pointing to the same conclusion, but the above citations fairly serve to show the character of the observations which led to the conclusion that water had no part in these exhalations.

It has seemed to the writers, in considering this problem, that evidence of this kind is unconvincing. Such evidence may serve to prove that the cloud above Kilauea does not consist entirely of steam, but it is a very different matter to conclude from it that no steam is emitted, particularly in view of the fact that the extensive hygrometer measurements offered by Brun all show that the observations were made in an unsaturated atmosphere, and the further fact that the temperature of the gases at the moment of emission was not far from 1200°. The latter point seemed to us of vital importance in any attempt to identify volcanic gases, for nearly all the recorded analyses of the gases contained in volcanic rocks[2] include gases (e.g., CO or $H_2$) which undergo immediate alteration and lose their identity if released into the air at such a temperature as 1200°. We therefore undertook the somewhat hazardous task of going to the bottom of the crater itself and collecting the gases direct from the liquid lava *before they had come in contact with the air* at all.

The gases were collected under the following conditions. A lava fountain broke thru the floor of the crater beside the lava lake and by its own spattering quickly built for itself an enclosing dike. When this dike had grown to a completely enclosing dome, an ideal gas collector was provided by the volcano itself; for this dome, because of the continual bursting of great gas bubbles within, was lined with the same liquid lava from which the gas was being released. From the narrow cracks in the sides of the dome, sheets of pale blue flame could be seen burning at night, which indicated (1) an excess pressure within, and in consequence (2) that the gases released from the liquid lava first came in contact with the air upon emerging from the dome.

[2] R. T. Chamberlin, The gases in rocks, Publications of the Carnegie Institution of Washington, No. 106. 1908.

We accordingly chose a favorable opportunity, descended into the crater and inserted a tube directly into one of these cracks behind the flame which was burning there. This tube was connected with a pipe-line some 7 or 8 meters in length, leading to a train of 20 collecting tubes, each of one-half liter capacity, and finally to a piston pump with a capacity of abour 2½ liters per stroke. The splashing of the lava within the dome could not only be heard and seen thruout the 15 minutes during which the pumping was continued but the jar could be felt beneath the observer's feet. The temperature at which the gases entered the tubes was about 1000°.

With the first stroke of the pump water began condensing in the glass tubes in considerable quantity, in plain view of the observers. This water, tho unexpected (in view of the statement of Brun) also served as a most excellent wash bottle by means of which to trap the halogens or other soluble salts asserted by Brun to be present. At the close of the pumping the tubes were sealed and taken out of the crater without mishap. Four days later the contents of Tube No. 3 were removed for preliminary analysis at the College of Hawaii in Honolulu. With the limited facilities there available, no very elaborate analysis was possible, but the following gases were found:

TABLE I

| | Weight Per cent |
|---|---|
| $SO_2$ | 51.6 |
| $CO_2$ | 39.8 |
| CO | 5.5 |

It was not possible to analyze for $H_2$ or $N_2$, but a 1 : 1 mixture of the gas residue with air gave no explosion on test. The tube also contained about 50 cc. of water with sufficient free sulfur to make it appear quite turbid. This water, when filtered and treated with acid silver nitrate, showed no trace of chlorine. No titanium was found.

The remaining tubes were transported to the Geophysical Laboratory in Washington at the close of the field season (nearly a year later) and analyzed there. The analysis of the fixed gases contained in five of the tubes is tabulated below.

TABLE II

ANALYSES OF THE FIXED GASES (PROPORTIONS BY VOLUME)

| | TUBE 1 | TUBE 2 | TUBE 9 | TUBE 11 | TUBE 17 |
|---|---|---|---|---|---|
| $CO_2$ | 23.8 | 58.0 | 62.3 | 59.2 | 73.9 |
| CO | 5.6 | 3.9 | 3.5 | 4.6 | 4.0 |
| $H_2$ | 7.2 | 6.7 | 7.5 | 7.0 | 10.2 |
| $N_2$ | 63.3 | 29.8 | 13.8 | 29.2 | 11.8 |
| $SO_2$* | none | 1.5 | 12.8 | none | none |
| Rare Gases | none | none | none | none | none |
| Hydrocarbons | none | none | none | none | none |

*** Inasmuch as all the tubes contained water, practically all of the $SO_2$ had gone into solution in the water and become altered before the final analysis was made.**

TABLE III

ANALYSES OF THE WATER (PROPORTIONS BY WEIGHT)

| | 1<br>*grams* | 2<br>*grams* | |
|---|---|---|---|
| $Na_2O$ | 0.0214 | 0.031 | The major portion of these may have come from the glass or from Pele's hair. |
| $K_2O$ | 0.0102 | 0.011 | |
| CaO | 0.0120 | 0.14 | |
| $Fe_2O_3$ / $Al_2O_3$ | 0.080 | 0.010 | |
| Cl | 0.220 | 0.206 | |
| F | 0.565 | 0.492 | |
| $NH_3$ | 0.0018 | none | |
| $TiO_2$ | 0.005(?) | none | |
| Total S as $SO_3$ | 0.480 | 0.508 | |

The conclusions from these analyses may be briefly recounted as follows:

(1) To anyone familiar with gas equilibria, it is immediately obvious that this group of gases can not exist together in equilibrium at a temperature of 1000° or more, but must be in process of active reaction at the time of release from the liquid lava. Reaction will begin between the gases in the rising lava column the moment pressure has diminishd to the point where they begin to be released from solution. As the lava rises to the surface, the pressure upon it diminishes steadily, setting free a continually increasing quantity of gas which is then free to enter into new chemical relations. Moreover, these reactions (e.g., $H_2 + SO_2$ and $H_2 + CO_2$) are of a kind to produce heat in such

quantity as seriously to affect if not to determine the temperature of the whole mass. This chemical activity will be a maximum at the surface at the moment of discharge into the atmosphere and the proportions of the reacting gases will vary with every bubble which bursts from the liquid lava, as is plainly shown by the variations from one tube to another in the above analyses.

It would seem to be a necessary consequence of this mode of release of the gases previously in solution and the resulting exothermic reactions between the gases after release, that the temperature of the lava lake should rise when the quantity of gas given off is large, and should diminish again when the gaseous exhalation diminishes in volume, and this was found to hold true thruout the activity of the summer of 1912 of which we were witnesses. The measured changes in temperature in the lava basin in this interval of about four months (the quantity of lava in the basin remaining practically constant) amounted in maximum to 115° (June 13, 1912, 1070°; July 6, 1912, 1185°).

(2) The exhalation unquestionably contains water, of which about 300 cc. were found condensed in our tubes. In view of the fact that the water condensed and remained behind while the fixed gases passed on thru the tubes and pump, it is not possible from these observations to estimate the proportion of water to the fixed gases.

(3) The presence of free S, $SO_2$ and $SO_3$ in the cloud affords adequate explanation of the phenomena observed by Brun. The visible cloud consists mainly of free sulfur (not of chlorides) and we were able to collect it from the cloud, both at the point of emergence and at the crater rim where Brun's observations were made. It follows from this that the cloud would not evaporate in the air nor show optical phenomena (rainbows), neither could it be expected to condense upon the crater walls, nor in tubes, if the point of collection was too far away from the point where the gases were released from the lava. The observations of fact made at Kilauea by Brun are for the most part confirmed by our observations, but we were unable to discover in them any basis for his conclusion that the exhalation is anhydrous, for the tiny sulfur particles would supply abundant nuclei of condensation for any

water in excess of the quantity required to saturate the atmosphere and any quantity smaller than this would evaporate freely in the comparatively dry air at 1300 meters elevation. Furthermore, Brun's observation that the exposure of a dew-point hygrometer within the cloud showed less moisture present than in the clear air outside, finds equally ready explanation in the fact that the cloud has been shown to carry $SO_2$ and $SO_3$, and by consequence sulfuric acid, which are excellent dehydrating agents. A cloud charged with drying agents like these must, *a priori*, be found drier than the surrounding air which is not provided with such drying agents. In confirmation of this we find that the decomposition of the surface lava, which is continually exposed to these gases, is everywhere a sulfuric acid decomposition, the decomposition products being sulfates (alum, gypsum) together with considerable quantities of free sulfur.

(4) If the total quantity of gas drawn into our tube system be estimated at about 1000 liters, then the quantity of chlorine is less than 0.02 per cent. In confirmation of this low chlorine content, analyses of the lava near the volcano which has been constantly exposed to the smoke cloud for 20 years or more, showed no test for chlorine in a 2 gram sample.[3]

(5) It is of the highest importance to note further that the nitrogen exhaled by the volcano contains no argon. Bearing in mind that argon is always present in the atmosphere in measurable quantities, and that it enters into no chemical combination whatever, it would seem to be a necessary conclusion that the atmosphere does not contribute to the gases which are given off by the lava. If atmospheric ingredients were present in the lava, then surely the argon must be given off again. This must apply to all atmospheric ingredients including water, whether originally gaseous or condensed, for if meteoric water were to

[3] Brun appears to have tested for chlorine with a silver nitrate solution in an atmosphere which is shown above to contain S, $SO_2$ and $SO_3$, and notes that it immediately becomes clouded, but mentions no test to ascertain whether it was the chloride or the sulphite which was thus precipitated. Similarly, he nowhere offers a chemical analysis of the particular gases which he collected in tubes at Kilauea, but contents himself with presenting two analyses of other gases pumped from solid lava fragments reheated *in vacuo* some months afterward. (L'Exhalaison Volcanique, p. 115.)

find its way into the lava it must do so as a gas and on the same terms as the other atmospheric gases, for the reason that the critical temperature of water is but 374°, whereas the lava temperature is 1000° or higher. It is therefore plain that capillary phenomena (Daubrée) can not be invoked to assist in the transmission of water into the liquid lava in the temperature region between 374° and 1000° in which $H_2O$ has no surface tension. But quite apart from this, there is no more reason for assuming that the water is of atmospheric origin than for assuming the carbon compounds to be so.

In conclusion, we may add that the much discussed question whether water is an active participant in volcanic activity appears to find adequate answer in these preliminary experiments, so far as Kilauea is concerned. Not only was water actually collected in considerable quantity (300 cc.) directly from the liquid lava, at a temperature of 1000° or higher, but this was done under conditions which completely excluded contamination with air. Moreover, the presence of free hydrogen associated with $CO_2$ and $SO_2$ at this temperature is of itself a sufficient guarantee of the presence of some water among the volcanic gases. Indeed, the reaction between $H_2$ and $CO_2$ (the water gas reaction $H_2 + CO_2 \rightleftarrows CO + H_2O$) has long been well known and has been studied in great detail.[1]

## BOTANY.—*The botanical name of the lime,* Citrus aurantifolia. WALTER T. SWINGLE, Bureau of Plant Industry.

The lime, altho closely related to the lemon and the citron, differs from them in having small white flowers, fewer stamens, thin-skinned fruits and winged petioles articulated with the blade of the leaf. Because of these and other divergent characters it seems proper to recognize it as a distinct species, as has been done by many botanists. It is quite distinct from *Citrus hystrix*, D. C., which is considered by Bonavia[2] to be the ancestral

[1] F. Haber, Thermodynamik technischer Gasreactionen. Berlin, 1905.

[2] Bonavia, E., 1886, On the probable wild source of the whole group of cultivated true limes (*Citrus acida* Roxb., *C. medica*, var. *acida* of Brandis, Hooker, and Alph. de Candolle), in Journal Linn. Soc., Botany, **22**: 213–218, figs. 1–3, (n. 145, Jul. 23).

form from which the cultivated lime was derived and to which Urban[3] refers the lime as a variety.

The earliest postlinnean binomial name applied to the lime was *Limon spinosum*, published by Philip Miller in 1768 in the 8th edition of his Gardener's Dictionary. The specific name spinosum cannot be transferred to Citrus because it would be a homonym of *Citrus spinosus* published by Gmelin in 1774[4] for a form of the lemon quite unlike the lime. The next oldest name, *Limonia acidissima*, was published by Houttuyn[5] in 1774 in spite of the already existing name *Limonia acidissima* used by Linnaeus for the wood apple of Ceylon and India, which name Houttuyn ruled out because he considered it inappropriate, rechristening the wood apple *Limonia pinnatifolia*. Under the rules of botanical nomenclature, no such substitution of names is permitted no matter how inappropriate the original name may be.

The *Limonia acidissima* of Houttuyn was undoubtedly the common lime of the East and West Indies as it was based on the Limonellus sive Limon Nipis of Rumphius[6] and also on an excellent plate published in 1705 by Juffrouw Marie Sibylla Merian,[7] the famous illustrator of insects who spent two years at the beginning of the eighteenth century in Surinam drawing and studying the insects of that colony and the plants upon which they feed.

In 1777 Christmann[8] in the German adaptation of Houttuyn's great work renamed the lime *Limonia aurantifolia*, this name being an avowed substitute for the invalid *Limonia acidissima* of

[3] Urban, I, 1905, Symb. antil., **4**: 321, as *Citrus Hystrix acida*.

[4] Gmelin, S. G., 1774, Reise durch Russland, St. Petersburg, **3**: 278–279.

[5] Houttyun, Martin, 1774, Natuurlyke historie . . . , volgens het samenstel van den Heer Linnaeus, Amsterdam, Deel 2, **2**: 444–445.

[6] Rumphius, G. E., 1741, Herb. amboin., Amsterdam, **2**: 107. tab. 29.

[7] Merian, Maria Sibylla, 1705, Metamorphosis insectorum surinamensium ofte veranderung der surinaamsche insecten, Amsterdam, p. 17, pl. 17 (s. d. but published 1705 vide Hagen, H. A., Bibl. Entom. **1**: 534–535). As Houttuyn does not specify the edition of Merian's work, it may be that he quotes from the second Dutch edition, published in 1719. Color is given to this surmise by the fact that the quotation made by Houttuyn differs by one word from the original text of Juffrouw Merian as published in 1705.

[8] [Christmann, G. F.], 1777, in Linné, Pflanzensystem nach der vierzehnten lateinischen Ausgabe und nach des holländischen Houttuynischen Werkes übersetzt, Nürnberg, **1**: 618.

Houttuyn. The fact that Houttuyn's name was preoccupied and consequently untenable was doubtless realized by Christmann, altho he makes no mention of his reasons for changing the name. His description and citations of older literature, practically translated from Houttuyn, are ample to establish *Limonia aurantifolia* as a valid species.

The name *Citrus lima* was published by John Lunan in 1814[9] for the common lime and has been recently revived by Percy Wilson (North America Flora, **25**: 222, 1911). This name is a homonym, however, since it was used for the common lemon by Alexander Aitcheson before 1806.[10]

The name *Citrus limetta* Risso, commonly applied to the lime, was published by Risso in 1813[11] but refers distinctly to a variety of sweet lime having an abnormal fruit, probably a garden variety of hybrid origin and certainly not a true lime. This being the type of Risso's species, his name cannot properly be applied to the common acid lime.

The subsequently published names for the lime, such as *Citrus spinosissima* Meyer[12] 1818, *C. acida* Roxburg[13] 1832, *C. Notissimus* Blanco,[14] 1837, *C. Limonellus* Hasskarl[15] 1842, and the many varietal names under the various specific names for the citron, the lemon or *Citrus histrix*, D.C. need not be discussed here as Christmann's name has priority over all of them.

The oldest tenable name for the lime is therefore Christmann's *Limonia aurantifolia* which upon being transferred to Citrus, becomes *Citrus aurantifolia* (Christm.) n. comb.[16]

[9] Lunan, John, 1814, Hortus Jamaicensis, Jamaica, **2**: 451–452.

[10] [Aitchison, Alexander], 18 (?), in Encyclopaedia Perthensis, 2 ed. (?) Perth. **5**: 686. The "New and Complete American Encyclopaedia. . . . From the Encyclopaedia Perthensis with Improvements," New York (John Low), 1806, **2**: 578, gives a verbatim reprint of the description of *Citrus lima* in the edition cited above.

[11] Risso, A., 1813, in Ann. Mus. d'Hist. Nat. Paris, **20**: 195, pl. 2, fig. 1.

[12] Meyer, G. F. W., 1818, Primitae Flora Essequeboensis, Göttingen, p. 247.

[13] Roxburgh, W., 1832, Flora indica, Serampore, **3**: 390.

[14] Hasskarl, J. C., 1842, Flora, **25**, 2 (Beibl.): 43

[15] Blanco, M., 1837, Flora de Filipinas, Manila, p. 607.

[16] The genus Limonia was founded on plants with pinnate leaves. The specific name aurantifolia of Christmann undoubtedly means having orange-like leaves in contrast with the original *Limonia acidissima* of Linnaeus (the *L. pinnatifolia* of Houttuyn and of Christmann).

## ABSTRACTS

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GEOLOGY—*The Yentna District, Alaska.* S. R. CAPPS. Bulletin U. S. Geological Survey No. 534, pp. 72, with maps, sections, and views. 1913.

The geological formations that outcrop are: (1) a thick slate-graywacke series of undetermined age, but pre-Tertiary; (2) intrusive granites and diorites, probably of Jurassic age; (3) Eocene clays and sands with some lignite; (4) Tertiary gravels; (5) glacial moraines and outwash gravels; (6) recent stream deposits.

The gravel series which overlies the Eocene beds was found to be structurally conformable upon the Eocene, and to antedate by a considerable time interval the period of maximum glaciation. These gravels have hitherto been thought to be Pleistocene.

The placer gold of Cache Creek and the neighboring creeks is thought to have been derived from quartz veins in the slate-graywacke series. Its present distribution has been largely influenced by glacial erosion, the present placers being found only in those places where ice erosion was feeble, or where post glacial erosion has effected a reconcentration of the glacially scattered gold. On Twin Creek and its tributaries the placer gold is the product of post glacial concentration of gold from the Tertiary gravels. S. R. C.

GEOLOGY.—*Bismarck, N. Dak., folio.* A. G. LEONARD. Geologic Atlas of the United States, No. 181. U. S. Geological Survey in coöperation with North Dakota Geological Survey. 1912.

The formations represented range in age from Cretaceous to Recent. The Fox Hills sandstone (marine), the lowest of the formations, is exposed in the lower parts of the bluffs of Missouri River in the southern part of the area and in some tributary valleys. The base is not ex-

posed, but along the Cannonball River, just south of this area, the formation has a thickness of 200 feet. Overlying this over most of the area, in apparent conformity, are 650–700 feet of dark, gray, brown, and black shale and sandstone of the Lance formation (fresh water), the approximate equivalent of the Ceratops beds of Wyoming. In this there is at least one workable 5-foot bed of lignite.

Conformably overlying the Lance or "Somber beds" are the ash-gray and yellow shales and sandstone of the Fort Union (Tertiary), having a maximum thickness of 200 feet. In this are numerous beds of lignite ranging in thickness from a few inches to 35 feet,—thicknesses of 5 to 10 feet are common. In places the lignite has burned out along the outcrop baking the overlying shale to red or pink clinker. The Fort Union carries a rich fossil flora, many freshwater shells and a few vertebrate fossils.

The area, altho outside of the terminal moraines of the Wisconsin stage of glaciation, contains considerable glacial drift. Remnants of moraines, patches of till, and patches of boulders are found, the latter so abundant in places as to form a pavement. This drift, tho indicated on the map as probably of Early Wisconsin age, is in the text provisionally referred to the Kansan stage of glaciation, since the appearance is that of remnants of a much eroded deposit. The western limit of continental glaciation is 50 to 60 miles west of the Missouri in this latitude. Much of the dissection of the area is believed to have been accomplished in Tertiary time but it also appears that there has been a long period of erosion since the deposition of this drift. The valley of Missouri River the author regards as pre-glacial. The economic resources of the area are lignite, clay, gravel, sand, surface and underground waters, and a good soil. WM. C. ALDEN.

GEOLOGY.—*Geologic reconnaissance of a part of the Rampart Quadrangle, Alaska.* H. M. EAKIN. Bulletin U. S. Geological Survey No. 535.

The area treated is in central Alaska, between Yukon and Tanana Rivers west of the 150th meridian. The consolidated stratified rocks of the area include a greenstone group probably of late Paleozoic age, a limestone and schist group of earlier Paleozoic age, a slate, quartzite and schist group, in part of Lower Cretaceous age and a slate sandstone and conglomerate group, probably also of Mesozoic age. These groups trend northeast and southwest across the area in a series of belts, the succession from northwest to southeast being in the order given.

The consolidated stratified rocks are intruded by batholiths and thick sills of monzonite, by a complex system of dikes of widely varying rock types, and by pegmatite and quartz veins. Some pegmatite dikes have centers of pure vein quartz. The solid rocks are overlain locally by loosely cemented Kenai (Eocene) beds, and widely by alluvial deposits. The latter include flood plain deposits of the present streams, stream terrace deposits and high lying silts and gravels. Some of the high lying gravels are evidently beach deposits.

Gold occurs in the metamorphic rocks at a number of places but no workable deposit has been discovered. Placer gold is mined in stream terrace deposits and in the high lying beach gravels. Cassiterite occurs in commercial quantities in some of the gold placers. H. M. E.

ZOOLOGY.—*Description of a collection of unstalked crinoids made by Captain Suenson in Eastern Asia.* AUSTIN HOBART CLARK. Proceedings of the Biological Society of Washington, **26**: 177–182. 1913.

The crinoids listed and described are the following: from near Hong Kong, *Comanthus japonica* (J. Müller), *Zygometra comata* (A. H. Clark), *Catoptometra rubroflava* (A. H. Clark) and *Dichrometra flagellata* (J. Müller); of these only one, *Zygometra comata*, was previously known from this locality; from the Philippine Islands, *Oligometra serripinna* (P. H. Carpenter); from south of the Goto Islands, *Parametra orion* (A. H. Clark); and from northeastern Korea, *Thaumatometra tenuis* (A. H. Clark).

The faunal relationships of the east Asiatic coasts are discussed, and the thirty-six endemic species occurring between southern Japan and Korea and Cochin China are found to fall into four distinct categories: (1) East Indian species, occurring in the Philippine Islands and on the coast of Cochin China, and extending northward as far as Hong Kong, one of them possibly to Fuchow; (2) southern Japanese species, ranging from Tokyo Bay westward to the Korean Straits and thence southward along the Riu Kiu Islands to Formosa (Taiwan) and Hong Kong, where they occur together with East Indian forms; (3) Arctic species, inhabiting the cold water which bathes the continental shores of the Sea of Japan, and ranging southward as far at least as the Korean Straits, possibly even to Shanghai; and (4) Antarctic species, inhabiting the Pacific coast of Japan and reaching their southern limit at Tokyo and Sagami Bays. A systematic list of all the species recorded from the region is given, and the faunal division, to which each belongs, indicated.

A. H. C.

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JOURNAL
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VOL. III NOVEMBER 19, 1913 No. 19

MATHEMATICS.—*A useful type of formula for the interpolation and representation of experimental results.* L. H. ADAMS. Geophysical Laboratory.

Mellor, in his *Higher Mathematics,*[1] remarks, "The reader will perhaps have been impressed with the frequency with which experimental results are referred to a series formula of the type:

$$y = A + Bx + Cx^2 + Dx^3 + ---,$$

in physical or chemical text books. For instance, I have counted over thirty examples in the first volume of Mendeléeff's *The Principles of Chemistry* and more than this number in Preston's *Theory of Heat.*" It is well known that for the representation of experimental results limited power series often leave much to be desired, and that such formulae adequately represent the data only in comparatively few instances or over short ranges; and yet as indicated by the above quotation this fact is seldom appreciated. It is the purpose of this note to point out the advantage of functions other than power series and to advocate their more general employment in cases where power series obviously do not conform to the known general form of curve given by the measurements.

By far the larger number of physical changes follow laws as yet unknown, and so, until the precise theoretical function is ascertained, the experimental results in question can be represented only by some sort of empirical formula. In the choice of

[1] J. W. Mellor, Higher mathematics for students of physics and chemistry, p. 273.

the most suitable equation to be fitted to a given set of experimental results there is usually considerable latitude; but among the host of mathematical functions there will often be certain ones which from their peculiar characteristics or general shape are especially adapted to the data in hand. Nevertheless most chemists and physicists, who desire to fit their experimental results to some equation, turn blindly to the familiar power series. When the graph representing the results is obviously non-linear, the quadratic or parabola, $y = A + Bx + Cx^2$, is first tried; if a satisfactory fit is not obtained another term is added, and so on until there is sufficiently close agreement between the calculated and observed values thruout the range of observation.

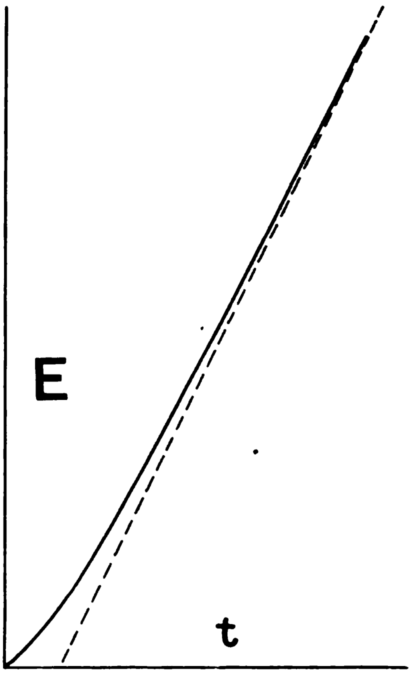

Fig. 1

Now it happens that in some cases a parabolic equation represents the relation between two physical quantities with great exactness. A notable example is the resistance of pure platinum, which is a quadratic function of the temperature between 0° and 1000° to within 0.05 per cent or better. Such accidents, however, are rare. More often than not a cubic or a fourth power equation is necessary especially for experimental observations of high precision. For instance, according to Bridgman[2] a power series of at least five terms—and probably more—would be required to represent the resistance of mercury as a function of pressure, with an accuracy of $\frac{1}{10}$ per cent, the degree of accuracy of the experimental work thruout the range of pressures investi-

[2] Proc. Am. Acad. **44**: 237, (1909).

gated (0–6000 atm.) As a first step in the search for a suitable equation it is advantageous to plot the data and to consider the general form of the graph, especially its limiting characteristics. As an illustration let us consider the e.m.f. of a copper-constantan thermoelement as a function of temperature. If we plot e.m.f. against temperature we obtain a curve of the type shown in figure 1.

The most important characteristic of this curve is its property of becoming more nearly linear the farther it departs from the origin. That is, the curve is asymptotic to a straight line (such as the dotted line shown in the figure), which does not pass

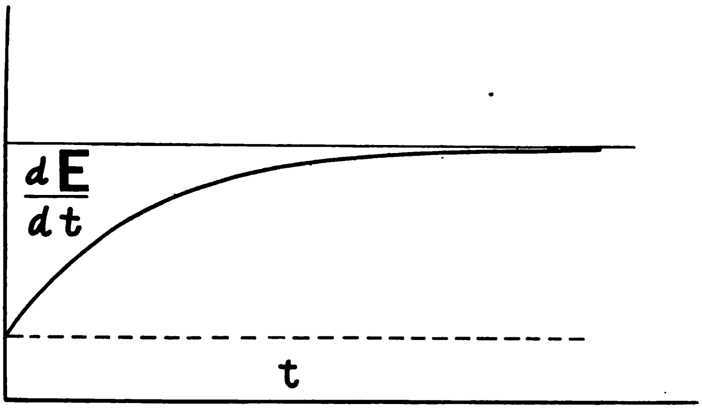


Fig. 2

thru the origin. It is apparent that neither a parabola nor a cubic equation (nor any power series with a reasonable number of terms) can conform over a wide range to this essential condition, namely, that of steadily increasing linearity with increasing values of **E** or $t$. A power series can be made to approximate only to a greater or smaller portion of the whole curve, the degree of approximation being better the greater the number of terms included in the series and the smaller the portion of the curve dealt with.

On the other hand there are a number of possible functions which have the desired general form. To derive one let us consider the course of the slope d**E**/d$t$ of the curve given in figure

1. The derivative is finite at the origin and increases with $t$, rapidly at first and then more slowly, tending toward a constant value as a limit (see fig. 2). Such a curve referred to the dotted line as the axis is given by $\frac{d\mathbf{E}}{dt} = 1 - e^{-t}$, in general by $\frac{d\mathbf{E}}{dt} = b(1 - e^{Ct})$, $C$ being a negative quantity;[3] or when referred to the $t$ – axis by equation $\frac{d\mathbf{E}}{dt} = a + b\ (1 - e^{Ct})$. Integrating and applying the initial condition that $\mathbf{E} = 0$, $t = 0$, we have, $\mathbf{E} = At + B\ (1 - e^{Ct})$. Where $A = a + b, B = \frac{b}{C}$. This equation is of the desired form, and, as we have found by trial, is highly satisfactory in a number of cases where the graph has the general form of figure I, as for instance, the relations between temperature and e.m.f. of copper-constantan thermoelements and between pressure and resistance of manganin or of "therlo" wire.

The calculation of the constants of this type of equation offers no especial difficulty: in fact it involves no more time or labor than in the case of the cubic equation:

$$\mathbf{E} = A't + B't^2 + C't^3$$

a form of equation which is often used and is in general of less utility. The method of evaluating the three constants, $A$, $B$ and $C$ is as follows: Write down three simultaneous equations containing pairs of corresponding values of $\mathbf{E}$ and $t$. Eliminate $A$ by addition or subtraction and $B$ by division; we then obtain an equation in $C$ of the form:

$$\frac{(1 - e^{t_1C}) - P\ (1 - e^{t_2C})}{(1 - e^{t_2C}) - Q\ (1 - e^{t_3C})} = \frac{\mathbf{E}_1 - P\ \mathbf{E}_2}{\mathbf{E}_2 - Q\ \mathbf{E}_3} = K$$

where $P = \frac{t_1}{t_2}$ and $Q = \frac{t_2}{t_3}$. Assume now several values of $C$ and with the aid of tables of the exponential compute the corresponding values of $K$. Then plot $K$ against $C$ and determine the proper value of $C$ by graphical interpolation. The value of $C$ being now known, $B$ and finally $A$ are readily calculated.

[3] Another suitable function is $\frac{dE}{dt} = a + b \tanh ct$ which would lead to the equation $E = aT + b \log \cosh ct$.

The result of the application of this equation to the copper-constantan element is shown in table I. The constantan wire consisted of selected lengths cut from a spool of No. 30 B. and S. "Ideal" wire made by the Electrical Alloy Co. The points at 100°, 217°.95 and 305°.9 were obtained by immersing the element (enclosed in a glass tube) in the vapors of boiling water, naphthalene and benzophenone;[4] those at the lower temperatures by comparison with an element[5] previously calibrated against a resistance thermometer. As table I shows, the curve when passed thru the three upper points fits the three lower points very satisfactorily; indeed the divergence is no greater than the experimental error.

TABLE I

COMPARISON OF OBSERVED E. M. F. (E) OF COPPER-CONSTANTAN ELEMENT WITH THAT CALCULATED FROM THE EQUATION $E = 74.672\,t - 13892\,(1 - e^{-0.00261\,t})$

| TEMP. | E (OBS.) MICROVOLTS | E (CALC.) MICROVOLTS | DIFFERENCE[1] MICROVOLTS |
|---|---|---|---|
| 24°.30 | 961.1 | 960.9 | 0.2 |
| 49°.59 | 2010.9 | 2010.8 | 0.1 |
| 78°.75 | 3291.7 | 3291.4 | 0.3 |
| 100°.00 | 4276. | (4276.) | ... |
| 217°.95 | 10248. | (10248.) | ... |
| 305°.9 | 15203. | (15203.) | ... |

[1]1 microvolt corresponds to about 0°.02.

The above equation as compared with a series formula containing a like number of constants (i.e., a cubic equation) possesses the following advantages, (1) In accord with what might be expected from the general shape of the curve a better agreement has been obtained between "observed" and "calculated" values. For instance if a cubic should be substituted for the exponential equation described, the differences in the fourth column of table I would each be greater than 5 microvolts (0°.1). (2) Since values of $(1 - e^{-x})$ may be obtained by inspec-

[4] Proper correction being made for barometric pressure. Cf. Adams & Johnston, Am. J. Sci., **33**: 538 et seq. 1912.

[5] This element belongs to Dr. W. P. White of this Laboratory. For description of the comparison of this element with the resistance thermometer, see Phys. Rev. **31**, 159. 1910.

tion and in one operation from tables of the Descending Exponential,[6] the operation of calculating a series of values from the exponential equation involves less labor than from a cubic equation. (3) Altho extrapolation is, in general, an operation beset with many pitfalls, nevertheless, if an extrapolation is unavoidable, it is more reasonable to employ a function of proper general form than to take some random function which can not be expected to fit the experimental results except over a small part of the range of observation.

MINERALOGY.—*Hodgkinsonite, a new mineral from Franklin Furnace, N. J.* C. PALACHE, Harvard University, and W. T. SCHALLER, Geological Survey.

The mineral here described was sent to the Harvard Mineralogical Museum for identification in April of this year by Mr. J. J. McGovern of Franklin Furnace, New Jersey. On being informed that the mineral was of a new species, material for further study and for analysis was freely supplied by Mr. H. H. Hodgkinson, M. E., Assistant Underground Superintendent of the mine, who first found the mineral in the mine workings and whose name it bears. Mr. Hodgkinson states that the new mineral was found in the northern part of the ore body, in that part of the Parker Mine formerly known as the Hamburg Mine and quite near the hanging wall of the west leg of the ore body, between the 850- and 900-foot levels. The locality was marked by a number of slips and faults, along some of which the mineral occurs. It has been found in a number of specimens during the year but nowhere in abundance.

Hodgkinsonite is a hydrous silicate of zinc and manganese crystallizing in the monoclinic system. It occurs in seams in massive granular ore of the typical willemite-franklinite mixture; the seams are generally very thin with but a film of the mineral which is always associated with white barite and not uncommonly with plates of native copper. Locally the film thickens to a narrow vein and then the new mineral may show individuals up to 2 cm. across, sharply angular in form and apparently with

[6] Such, for example, as those in Becker and Van Ostrand's hyperbolic functions (Smithsonian Mathematical Tables, Washington. 1909).

crystal faces but in reality determined in their outline almost wholly by the older platy barite which encloses them. The clear pink color and brilliant cleavage of hodgkinsonite, together with the snow white barite make such specimens both striking and attractive in appearance. One mass of ore with a surface 20 cm. square is at least half covered with hodgkinsonite. In one case only has such a vein been found in which the angular cells formed by the intersecting barite plates were not wholly filled by hodgkinsonite so that the latter was free to develop crystal planes. From this specimen three crystals of good quality were detached and these served to establish the axial ratio of the species.

Other crystals were found occupying cavities in thicker veins free from barite. These crystals, the largest 1 cm. long, were much affected by solution, the faces being generally dull or facetted. They were accompanied by black rhombohedral crystals of pyrochroite and scalenohedral crystals of calcite, both later in age and encrusting hodgkinsonite. The latter is implanted directly on willemite or franklinite and in one specimen on manganese garnet. The association and mode of occurrence both indicate a pneumatolytic origin for the new mineral.

Hodgkinsonite is monoclinic with normal symmetry. The highly perfect cleavage, normal to the symmetry plane, has been taken as the basal pinacoid. The elements were calculated from the angles of the forms taken as (110), (011), and (221) together with the inclination of the cleavage (001) to the prism zone. These angles follow.

$$(001)\left\{\begin{array}{l}\varphi = 90^\circ\ 00' \\ \rho = \phantom{0}5^\circ\ 27\tfrac{1}{2}'\end{array}\right\}\text{ Average of 2 readings on 2 crystals.}$$

$$(110)\left\{\begin{array}{l}\varphi = 33^\circ\ 10' \\ \rho = 90^\circ\ 00'\end{array}\right\}\text{ Average of 7 readings on 3 crystals.}$$

$$(011)\left\{\begin{array}{l}\varphi = \phantom{0}4^\circ\ 42' \\ \rho = 48^\circ\ 16'\end{array}\right\}\text{ Average of 2 readings on 1 crystal.}$$

$$(221)\left\{\begin{array}{l}\varphi = 34^\circ\ 48' \\ \rho = 69^\circ\ 48'\end{array}\right\}\text{ Average of 4 readings on 2 crystals.}$$

The axial elements thus calculated are:

$$p_0 = 0.7254 \qquad q_0 = 1.1114 \qquad \mu = 84^\circ\ 33\tfrac{1}{2}'.$$
$$a : b : c = 1.539 : 1 : 1.1165 \qquad \beta = 84^\circ\ 33\tfrac{1}{2}'.$$

The forms observed are $c(001)$, $m(110)$, $s(011)$, $r(221)$, $t(\bar{4}01)$, $x(\bar{3}05)$, $q(552)$, $u(\bar{3}22)$. The last four of these forms were found only on the etched crystals, which had been measured with considerable care before the better crystals were found. These four high-index forms are no doubt vicinal and due to etching of the crystals; they are nevertheless retained in the table of measurements and a figure showing them is given since they are characteristic of most of the specimens.

In the following table may be found all the observations made on these crystals, together with the calculated angles for the various forms.

TABLE 1

ANGLE TABLE FOR HODGKINSONITE

| | CALCULATED | | MEASURED | | LIMITS | | NO. OF FACES |
|---|---|---|---|---|---|---|---|
| | $\varphi$ | $\rho$ | $\varphi$ | $\rho$ | $\varphi$ | $\rho$ | |
| $c(001)$.... | 90°00′ | 5°27½′ | 90°00′ | 5°27½′ | | 5°27′– 5°28′ | 2 |
| $m(110)$... | 33 08 | 90 00 | 33 10 | 90 00 | 33°08′–33°11′ | | 7 |
| $s(011)$.... | 4 53½ | 48 15½ | 4 52 | 48 14 | 3 34 – 6 23 | 47 28 –48 47 | 12 |
| $r(221)$.... | 34 49 | 69 49 | 34 48 | 69 48 | 34 45 –34 51 | 69 35 –69 59 | 4 |
| $t(\bar{4}01)$.... | −90 00 | 70 28 | −90 00 | 70 09 | | 70 03 –70 15 | 2 |
| $x(\bar{3}05)$.... | −90 00 | 18 52 | −90 00 | 18 13 | | 17 36 –18 35 | 3 |
| $q(552)$.... | 34 29 | 73 33 | 34 30 | 72 34 | 34 01 –35 10 | 71 45 –73 23 | 4 |
| $u(\bar{3}22)$... | −41 47 | 56 16 | −43 15 | 55 25 | 42 59 –43 31 | | 2 |

The crystals are acute pyramidal in habit as shown in figure 1, and are dominated by the equal development of unit prism $m$ and pyramid $r$. On the etched crystals this pyramid is replaced by a group of facets whose average position corresponds to the symbol (552). The clinodome and prism faces are always smooth but often dull and poorly reflecting. The faces of other forms are minute and of the poorest quality. Figure 2 shows one of the etched crystals, doubly terminated and with the small faces of uncertain forms characteristic only of specimens of this type.

The perfect cleavage of hodgkinsonite is parallel to the basal pinacoid. The density is 3.91, determined by a pycnometer on

a gram of small fragments which were later used for analysis. The hardness is a very little less than 5.

The optical characters have been only imperfectly determined. The optic axial plane is parallel to (010). The mean refractive index is 1.73, determined by the immersion method. The color of the mineral varies from a bright pink to a pale reddish brown, the luster is vitreous, the streak white.

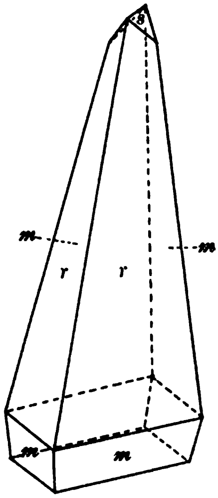

Fig. 1

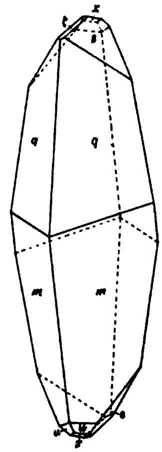

Fig. 2

Fig. 1. Hodgkinsonite. Common habit of implanted crystals, showing basal cleavage when removed from the matrix. Forms *m*(110), *s*(011), *r*(221). On etched crystals *r* is replaced by *q*(552) without change of habit.

Fig. 2. Hodgkinsonite. Doubly terminated etched crystal. Forms: *c*(001), *m*(110), *s*(011), *x*($\bar{3}$05), *q*(552), *u*($\bar{3}$22).

The mineral decrepitates when held in the blowpipe flame, wherein it fuses readily and quietly to a brown enamel. Heated in a closed tube, hodgkinsonite decrepitates strongly, splitting up into numerous thin cleavage scales which on further heating yield water and become brown in color. The mineral is readily soluble in acid, yielding gelatinous silica.

The chemical analysis of hodgkinsonite was made on carefully selected cleavage fragments of a clear pink color and gave the

following results. Quarter gram samples were used as the total amount of available material was only somewhat over a gram.

ANALYSIS AND RATIOS OF HODGKINSONITE (BY W. T. SCHALLER)

| | 1 | 2 | 3 | AVERAGE | RATIOS | |
|---|---|---|---|---|---|---|
| $SiO_2$ | 19.92 | 19.89 | 19.77 | 19.86 | 0.331 | 1.02 |
| MnO | 20.39 | 20.97 | | 20.68 | 0.291 | |
| ZnO | 52.93 | * | | 52.93 | 0.653 | 2.98 |
| CaO | 0.99 | 0.88 | | 0.93 | 0.017 | |
| MgO | 0.04 | | | 0.04 | 0.001 | |
| $H_2O$ | | | 5.77† | 5.77 | 0.321 | 0.99 |
| | | | | 100.21 | | |

* A duplicate determination of ZnO, of which a small amount was lost, gave 51.38 per cent.

† Determined directly by fusing the mineral with sodium carbonate and collecting the water in a calcium chloride tube. A determination of the loss on ignition, corrected for oxidation of the manganese, gave the value 4.68 per cent.

A doubtful trace of lead was encountered but iron and chlorine were absent. No water was given off by the mineral at 110°.

The ratios yield sharply the formula 3 $RO.SiO_2.H_2O$ where R is chiefly zinc and manganese. If the manganese, calcium and magnesium be arbitrarily taken together then the ratio of MnO + CaO + MgO to ZnO is 309 to 653 or 1 : 2.11 or nearly 1 : 2. The formula may then be written $MnO.2ZnO.SiO_2.H_2O$ which may, as the water is all constitutional, be interpreted as $Mn.(ZnOH)_2.SiO_4$.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

A special meeting of the Society was held on October 28, 1913, at the National Museum.

Dr. Ales Hrdlicka addressed the Society, his subject being *The results of the speaker's recent trip to Peru; with remarks on the anthropological problems of Peru,* illustrated with lantern slides. In 1910 the speaker made a brief exploratory trip in Peru, which resulted in the acquisition of some valuable data and of important skeletal collections. The opportunity to extend the investigations came during the early part of the current year, in connection with the preparation of the anthropological exhibits for the Panama-California Exposition at San Diego; and as a consequence three busy months were spent on the Peruvian coast and in certain parts of the mountain region of Peru, in exploration of the ruined cities and ancient cemeteries. The principal objects of the trip were, first, the mapping out as far as possible of the anthropological distribution of the prehistoric Peruvian, more particularly the coast people; second, the determination of the physical type of the important Nasca group of people, which represent one of the highest American cultures; third, further inquiry as to man's antiquity on the west coast of South America; and fourth, the extension of the speaker's researches on pre-Columbian pathology. The conclusions to which the speaker was formerly led were in the main corroborated. In regard to the mountain regions much remains to be determined in the future. As to the pathology of the native Peruvian before contact with whites, the main work can perhaps be now regarded as done, or nearly so, altho individual variation in different morbid processes seems inexhaustible, and much in this line remains to be secured by future exploration. The ground covered was extensive and the skeletal material examined was enormous, the selections alone filling over thirty boxes. No excavation was practiced, attention being restricted, on the coast, to the bones covering the surface of ancient cemeteries, exploited by the peons, and to burial caves and houses in the mountains.

Since the speaker's trip to Peru three years ago, a change for the worse was observed in the state of preservation of the ancient remains. Also, where formerly there were seemingly inexhaustible quantities of skeletal material there is now a dearth of it. No such collection as that made in 1910, when the speaker gathered 3400 important crania, will ever again be possible from these regions. The major part of the

old population of the coast region belongs to the brachycephalic type intimately related to the Maya Zapotec type in the north. Wherever they lived, these people of the Peruvian coast were wont to practice, more or less, the antero-posterior head deformation. Everywhere along the coast there are evidences of more or less admixture with a more oblong headed element closely related to the Aztec and Algonquin types of North America. As among the North American Pueblos, nowhere was the aboriginal Peruvian population at any time as great as the relatively numerous cemeteries or ruins might lead one at first to suppose, for these burial grounds and ruins date from different, altho not far distant, periods.

The work done, while to some extent establishing a foundation, is merely a fair beginning. Similar investigations and collections wait urgently on the anthropologist in the important districts of Piura, Eton, and Moquegua, on the coast; in the western sierras from the neighborhood and latitude of Cajamarca to those of Arequipa; and in the eastern highlands from Tiahuanaco to Moyobamba. The most important problems that await solution are (1) the derivation of the Peruvians; (2) the time of their advent into the country; (3) the extension and exact physical characteristics of the Aymara and Quechua; and (4) the genetic relations of the Peruvian to the Argentinan and Chilean aborigines. Besides this there remains to be established in many places the correlation of culture with the physical type of the people. The speaker repeated what he said in a former report, that, due to the lack of scientific supervision of a great majority of the excavations practiced in Peru to the present time, the archeological collections from that country are made up of little more than curiosities which it is impossible to refer either to any definite people or period.

DANIEL FOLKMAR, *Secretary.*

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Vol. III. No. 20

December 4, 1913.

# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES



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JOURNAL
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VOL. III DECEMBER 4, 1913 No. 20

PHYSICS.—*Determination of the zonal variation of the equivalent focus.* E. D. TILLYER. Bureau of Standards. Communicated by FRED. E. WRIGHT.

The method of lens testing developed by Hartmann[1] in 1904 has given a very efficient means of determining the grouping of the light rays after passage thru a lens system. This method is laborious and difficult when applied to the zonal variations of the equivalent focal length. In the present paper it is proposed to show how one set of measures gives both the variations of the position of the focus and of the equivalent focal length: also, by making several sets in light of different wave lengths, the axial and oblique chromatic aberrations can be obtained.

A diagramatical sketch of the apparatus used, is given in figure 1. A nearly parallel beam of light from a distant monochromatic source falls upon a metal plate $P$ pierced with small holes, only two of which are shown, forming light rays which pass thru the lens system and are refracted in the normal manner. A shadow photograph is taken upon a plate placed close to the lens, a second at a considerable distance on the other side of the focus. These shadow images are not as sharply defined as when both exposures are made close to the focus. If, however, care is taken, a dark center diffraction disk can be obtained which increases the ease and accuracy of a setting.

Now consider the position of any ray $R$ (fig. 1) with reference to the axial ray. Let $a$, $b$ equal the distances of this ray from the

[1] Hartmann, Zeitschr. f. Instrumentenkunde. 1904.

axis in the planes $A$ and $B$ respectively, let $d$ equal the separation of these two planes and $v$ the distance from $A$ of the intersection of this ray with the axial ray, then we have

$$v = \frac{a\,d}{a+b}$$

which is the position of the focus as given by Hartmann. A variation of $v$ as $\Delta v$ from the limiting paraxial value is the spherical aberration.

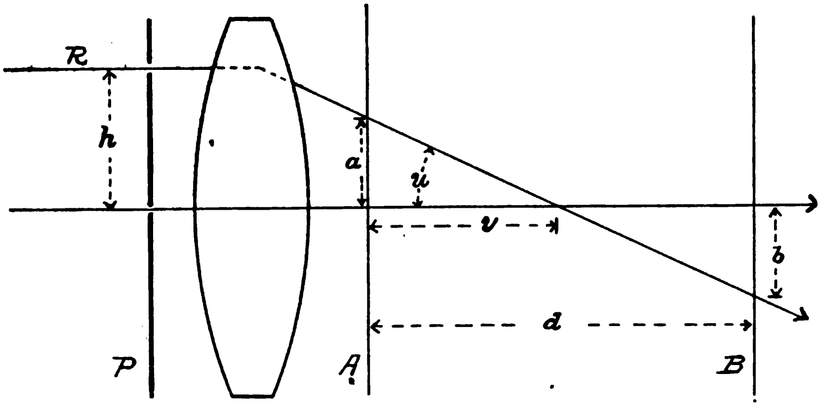


Fig. 1

Abbe has shown that, if we assume no spherical aberration, a lens will be free from coma for points near the axis when the "sine condition" is fulfilled. If the object is at infinity this reduces to

$$E = \frac{h}{\sin u}$$

where $E$ is the equivalent focal length, $h$ is the distance from the axis of the entering ray and $u$ is the angle this ray makes with the axis after refraction. If $E$ varies from the limiting zero value, as $\Delta E$ when $h$ varies, the lens has a different equivalent focus for each zone. It can be shown in a lens without artificial stops and with spherical aberration, that the corresponding condition for freedom from zonal variation of equivalent focus (coma near the axis) is $\Delta E - \Delta v = 0$.

The metal plate used for isolating the individual rays has been calibrated, and the height $h$ determined; the angle $u$ can be obtained from

$$\tan u = \frac{a+b}{d} = \frac{a}{v},$$

and consequently $E$ and $\Delta E - \Delta v$. This set of measures can be repeated for different wave lengths, and the variations in the quantities determined; from $\Delta v$ we find the axial chromatic aberration and the departure from the Gauss condition, and from $\Delta E - \Delta v$, the oblique chromatic aberration and the variation of coma with color.

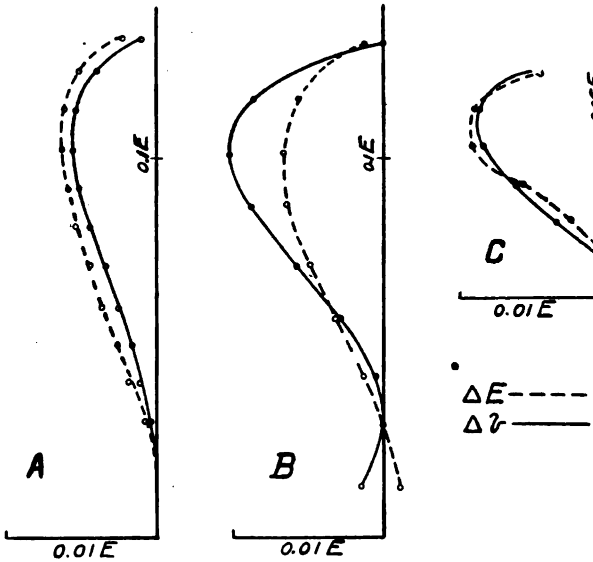


Fig. 2

The diaphragm plate, generally used with moderate size lenses, has holes of 1 mm. diameter arranged in a line and located at about 3 mm. intervals. The error in the known position of the holes is less than 0.005 mm. which corresponds to an error of about one part in ten thousand in $\Delta E$ for the edge ray of an ordinary small lens. The shadowgraphs are easily measured on a small Zeiss comparator with sufficient accuracy for rays somewhat

distant from the center. Near the axis it is almost impossible to obtain an accurate value of either $\Delta E$ or $\Delta v$ and the problem becomes physically indeterminate.

This method was first tried upon a telescope objective of 320 mm. equivalent focus, the trigonometric residuals of which were already known.

TABLE 1

TELESCOPE OBJECTIVE, $E = 320$, $\lambda = 0.55\ \mu$. RESIDUALS IN HUNDREDTHS OF A MILLIMETER

| h in mm. | | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 27.5 |
|---|---|---|---|---|---|---|---|---|---|
| Obs.......... | Δv............ | +0 | +17 | −1 | −7 | −1 | −7 | −1 | |
| Obs.......... | ΔE-Δv........ | +4 | − 2 | +4 | −8 | 0 | −2 | +3 | |
| Comp........ | Δv............ | 0 | − 1 | −2 | −3 | −5 | −6 | −5 | +5 |
| Comp........ | ΔE-Δv........ | 0 | 0 | 0 | +1 | +1 | +1 | 0 | −1 |

From these residuals it is seen that the probable error of a determination near the edge of the objective is only a few hundreths of a millimeter. Moreover it is evident that this objective is exceptionally well made.

The results of measurement of the spherical aberration and departure from the sine condition for three photographic objectives are plotted in figure 2. Curves *A* and *B* were made from high speed anastigmats with an aperture ratio of about F 3.5 while curve *C* is an older much used type of symetrical anastigmat having an aperture ratio of about F 7.7. One peculiar feature of curve *B* is the difficulty experienced in determining the relative positions of the zero values of *E* and *v*, the *v* curve apparently having a point of inflection near the axis. This may be due to a small error in grinding the surface, to an error in the measurements, or to a true aberration in this type of lens. Some evidence exists that this is a true aberration since the actual coma found in this lens changes sign at only a small angle with the axis. Both lenses, however, are remarkable for their freedom from aberrations and for the care taken in their construction.

CRYSTALLOGRAPHY. *The change in the crystal angles of quartz with rise in temperature.* FRED. E. WRIGHT. Geophysical Laboratory.

Crystallographers agree that in the development of the science of crystallography the two minerals, quartz and calcite, have played an exceedingly important rôle. Quartz was the first crystal substance to attract the attention of the ancient Greeks. They observed that its crystals are bounded by plane and not curved surfaces, as is the case in plants and animals; and they named it "crystal," i.e., clear ice, on the assumption that it had been formed from water thru the action of intense cold. Later they found that other substances had different but equally characteristic shapes and they accordingly extended the term "crystal" to signify the state of being bounded by flat surfaces rather than to denote the mineral quartz to which the name "rock crystal" is still applied occasionally. Further observations on crystals were not made until 1669, when Nicolaus Steno, a Danish physician, found that the angles between any two corresponding quartz crystals were the same even tho the shapes and sizes of these faces varied from crystal to crystal. Steno's law of the *constancy of crystal angles* is of fundamental importance and on it all subsequent work in crystallograpy has been based. Steno's observations were made at room temperature and under ordinary atmospheric pressure, and practically all subsequent measurements of crystal angles have been made under similar conditions of pressure and temperature, with the result that these two factors have been less carefully considered by crystallographers than their importance possibly merits.

We may look upon a crystal as a system of forces which finds expression in the development of the crystal faces and in the other crystallographic properties and which, in turn, exerts a definite influence on external forces, either physical or chemical, within the range of its action. This system is not invariant but has two degrees of freedom, temperature and pressure, and, even tho their effects may be relatively slight, yet their recognition and study should furnish data of value. In physical chemistry the investigation of the temperature-pressure effects on chemical-

physical systems has led to results of the greatest interest. In crystallography the relations between the differential changes in the crystallographic properties and the attendant differential changes in the optical and other constants should lead to differential equations which on integration would state the relations between the two systems of forces (crystallographic and physical) and thus give us information on the character and order of magnitude of the crystallographic forces themselves. It is essential in this connection to measure not only the changes in the crystallographical and optical constants with temperature and pressure but also the specific heats at the different temperatures (energy changes). The measurement of these properties on a few selected minerals is now being carried out at this Laboratory. In the present preliminary paper the results of the measurements of the changes in the crystal angles of quartz with temperature are presented briefly.

*Method and apparatus.* The quartz crystals were measured on the thermal two-circled goniometer described recently in this journal.[1] With this goniometer the position of the normal to each crystal face in space was fixed by two angles (angular polar distance and azimuth angle) for each measured temperature. The crystal was mounted in platinum jaws and securely fastened. No effort was made to adjust the crystal accurately because it was evident that any mechanical device consisting of different materials would not remain fixed in position over a temperature range of 1200°. The entire crystal was first measured at room temperature and then the furnace heated to a definite temperature, and held there 5 or 10 minutes; at this temperature the entire crystal was remeasured, the temperature being held constant during the measurement and the angular values on several of the faces repeated to insure constancy of position of the crystal during the readings. This procedure was repeated at each temperature of measurement up to 1250°. By this method adjustment troubles are eliminated and the measurement of the entire crystal is complete for each temperature and independent of previous adjustment and of any slight shifts in position which may have occurred.

[1] Journ. Wash. Acad. Sci., 3: 396–401. 1913.

From the position angles of the faces thus measured the angles between the unit rhombohedrons over the pole were computed; also the angle between the unit rhombohedron and the prism face immediately below it.

During the measurements the adjustment of the goniometer was tested and found satisfactory. Readings were made to ¼′ of arc, the circle being graduated to ½′.[2] At the high temperatures the light from the furnace itself is so intense that an arc light is re-

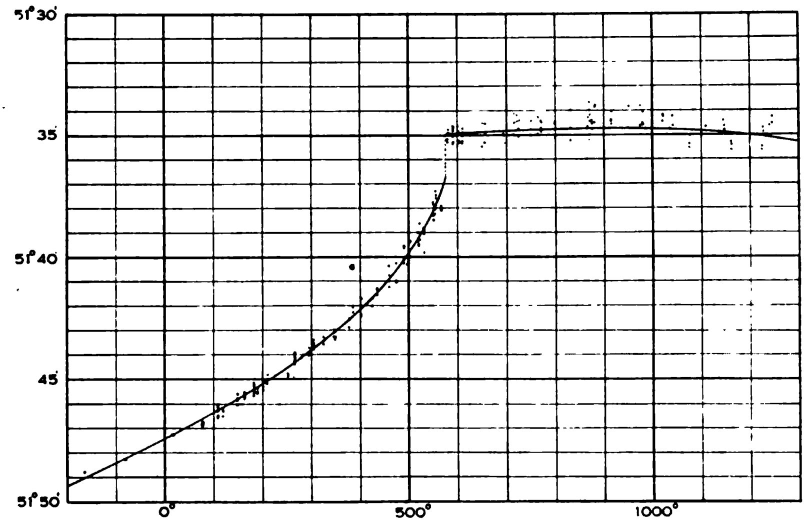


Fig. 1

quired for illuminating the signal. The light of the furnace was cut out to a large extent by means of a blue filter (Wratten tricolor blue) which absorbed all of the red and yellow and most of the green of the spectrum, colors which are most intense in the furnace, whereas the arc light emits relatively more blue light. At 1250° the signals observed thru this filter were perfectly sharp and the measurements were as easy to make as at room temperatures.

The results of measurements are listed in Table 1 and are represented graphically in figure 1.

[2] In making the readings the quarters of minutes were recorded as follows: ¼′ = 1.; ½′ = 1˙; ¾′ = 1:; this method of indicating the quarter minutes was found convenient and satisfactory in practice.

TABLE 1

| TEMPERATURE IN DEGREES | DECREASE IN ANGLE ρ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE ρ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE ρ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE ρ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE ρ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE ρ IN MINUTES SERIES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 0.0h | 180 | 1.9k | 305 | 3.6f | 426 | 5.7f | 531 | 8.2g | 602 | 11.8h |
| 20 | 0.0e | 181 | 2.0d | | 3.9f | | 6.1f | | 8.5g | | 12.2h |
| | i | | 1.6d | | 4.1f | 437 | 5.9e | | 7.9g | | 12.4h |
| 21 | 0.0a | | 2.1d | 326 | 4.0e | | 5.4e | | 8.0k | | 12.6h |
| | f | 185 | 1.9e | | 3.8e | | 5.8e | | 7.8k | 613 | 12.0k |
| | g | | 1.7e | | 3.5e | | 6.0e | 552 | 9.0d | | 11.9k |
| 22 | 0.0b | | 1.9e | | 3.7e | 461 | 6.0b | | 9.2d | | 12.3k |
| | k | | 2.0e | 330 | 4.0l | | 5.9b | | 9.6d | 614 | 12.2l |
| 23 | 0.0c | | 2.3e | | 3.9l | | 6.3b | 554 | 8.9b | | 12.2l |
| | d | 190 | 1.9l | | 3.8l | | 6.9b | | 9.7b | | 11.5l |
| | l | | 1.8l | | 3.9l | 484 | 7.0g | | 9.7b | | 12.0l |
| 79 | 0.5i | | 2.1l | | 4.2l | | 7.6g | | 9.1c | | 12.5l |
| | 0.4i | | 2.2l | 341 | 3.9i | | 6.3g | | 9.2c | 636 | 12.2e |
| | 0.7i | | 2.2l | | 4.0i | | 7.0g | | 9.0c | | 11.9e |
| 108 | 1.1e | 203 | 1.8i | | 4.3i | 494 | 7.5d | | 9.0c | | 12.2e |
| | 0.7e | | 2.0i | 344 | 4.2k | | 6.9d | 560 | 9.6l | | 12.4e |
| | 1.0e | | 2.2i | | 4.0k | | 7.7d | | 8.9l | 647 | 12.7d |
| 110 | 0.8f | 206 | 1.8a | | 4.3k | 500 | 7.0h | | 9.6l | | 12.3d |
| | 1.2f | | 2.2a | 346 | 3.9c | | 7.1h | 552 | 9.5h | | 11.9d |
| | 1.2f | | 2.2a | | 4.0c | | 7.6h | | 9.5h | 670 | 12.3c |
| 111 | 1.1c | 213 | 2.1f | | 3.8c | | 7.7h | | 9.7h | | 11.7c |
| | 1.0c | | 2.2f | | 3.9c | 504 | 7.2c | | 9.5h | | 12.2c |
| | 0.7c | | 2.3f | 377 | 4.2b | | 7.5c | 565 | 9.2d | | 13.3c |
| | 0.7c | | 2.2f | | 4.7b | | 7.6c | | 9.9d | 703 | 12.2h |
| | 1.2h | 255 | 2.4c | | 4.8b | 519 | 7.8l | | 10.3d | | 12.6h |
| | 1.2h | | 2.4c | | 4.4b | | 7.9l | 582 | 11.5f | | 13.1h |
| | 1.5h | | 2.5c | 392 | 4.4h | | 7.5l | | 12.1f | | 12.7h |
| 122 | 1.0a | 267 | 2.9g | | 5.0h | | 7.8l | | 12.3f | 713 | 12.2g |
| | 0.8a | | 3.2g | | 5.2h | 521 | 8.6b | 583 | 12.5d | | 12.5g |
| | 0.8a | | 3.4g | | 5.3h | | 8.0b | | 12.5d | | 12.8g |
| 151 | 1.2g | | 3.5g | 408 | 5.0d | | 7.9b | | 11.9d | 722 | 12.3i |
| | 1.5g | 272 | 3.0h | | 4.9d | | 8.2b | 592 | 12.0g | | 12.6i |
| | 1.5g | | 3.3h | | 5.6d | | 8.2f | | 12.5g | 731 | 12.8c |
| | 1.7g | | 3.1h | 426 | 5.0c | | 8.0f | | 12.2g | | 12.2c |
| 163 | 1.5b | | 3.4h | | 5.2c | | 7.5f | | 12.9g | | 12.4c |
| | 1.7b | 294 | 3.5d | | 5.6c | 531 | 8.2e | | 13.1g | | 12.1c |
| | 1.6b | | 3.2d | | 5.0c | | 8.4e | 595 | 12.4c | | 13.0c |
| | 1.7b | 302 | 3.5b | | 5.3f | | 8.2e | | 12.0c | 732 | 12.8e |
| 180 | 1.8k | | 3.1b | | 5.4f | | 8.2e | | 11.9c | | 12.4e |
| | 1.7k | | 3.7b | | 5.8f | | 8.2e | 602 | 11.8h | | 12.1e |

TABLE 1—CONTINUED

| TEMPERATURE IN DEGREES | DECREASE IN ANGLE $\rho$ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE $\rho$ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE $\rho$ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE $\rho$ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE $\rho$ IN MINUTES SERIES | TEMPERATURE IN DEGREES | DECREASE IN ANGLE $\rho$ IN MINUTES SERIES |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 750 | 12.3d | 806 | 12.7e | 865 | 13.6l | 938 | 12.9d | 1042 | 12.6h | 1144 | 11.3c |
| | 12.9d | | 12.6e | | 13.6l | | 12.9d | | 11.6h | | 13.6c |
| | 11.7d | | 12.7e | 866 | 12.7g | 971 | 12.7c | | 13.0h | 1203 | 11.6c |
| 769 | 12.7i | | 12.9e | | 13.4g | | 12.6c | 1058 | 11.7c | | 11.6c |
| | 13.0i | 857 | 13.6d | | 13.4g | | 11.8c | | 12.1c | | 11.2c |
| | 12.9i | | 13.6d | | 12.5g | | 13.2c | | 12.2c | | 11.3c |
| 770 | 12.8k | | 12.1d | 874 | 12.4i | 975 | 13.1l | | 11.3c | 1232 | 12.5g |
| | 12.9k | | 12.8h | | 12.4i | | 13.4l | | 11.0c | | 12.3g |
| | 12.5k | | 13.1h | 916 | 12.7k | | 13.6l | 1109 | 12.6l | | 12.4g |
| | 12.5k | | 13.2h | | 12.8k | | 12.3l | | 13.6l | | 11.3g |
| | 12.2k | 862 | 12.7c | | 13.2k | 993 | 11.5i | 1143 | 12.4k | 1235 | 12.6l |
| | 12.7k | | 12.6c | 929 | 12.8e | | 11.7i | | 12.6k | | 13.6l |
| 788 | 12.8l | | 12.8c | | 13.2e | 1020 | 12.8k | | 12.8k | | 12.7l |
| | 12.2l | | 12.7c | | 12.6e | | 13.0k | 1144 | 11.6c | | 12.2l |
| | 12.0l | 865 | 12.6l | | 12.1e | | 13.0k | | 11.9c | 1239 | 12.7k |
| | 12.7l | | 12.9l | 938 | 13.3d | 1042 | 12.6h | | 11.2c | | 12.9k |

NOTE: In this table the different sets of readings are lettered thus: *a* readings made on October 4; *b*, on October 7; *c*, on October 8; *d*, on October 10; *e*, on October 15; *f*, on October 17; *g*, on October 18; *h*, on October 22; *i*, on October 24; *k*, on October 27; *l*, on October 28, 1913. All crystals measured were from Herkimer Co., N. Y., and were kindly loaned to the Laboratory by the U. S. National Museum (Specimen No. 82925).

In Table 1 the computed changes in the polar angle $\rho$ for the unit rhombohedron $(10\bar{1}1)$ are given in place of the measured angles, which of themselves have no direct significance because the crystals were purposely not accurately adjusted before the measurement.

The heavy curve in figure 1 represents the average value of the observations. At 575° it has a noticeable discontinuity which marks the transformation of $\alpha$ into $\beta$ quartz; this is accompanied by a noticeable change in volume and also in the optical and crystallographical properties. At the inversion temperature the reflexion signals from all of the faces, both rhombohedron and prism, become temporarily (2 to 5 seconds) indistinct; the sharp signal widens out into a hazy patch of light, moves noticeably and

finally regains its original sharpness but has usually shifted its position noticeably in the field.

The form of the curve below 575° ($\alpha$-quartz) suggests an exponential curve. To test this conclusion the first, second and third derivatives were formed by the method of differences between values at constant intervals on the curve. The curves of these derivatives were similar in shape to the original curve, thus proving that the original curve can not be adequately represented by an ordinary polynomial equation up to the fifth degree. Accordingly an exponential function of the form

$$y = at + b\ (e^t - 1)$$

was tried with the following results, the constants $a$ and $b$ having been ascertained from the observed values by the least square method:[3]

$$y = 51°47'.4 - \left\{0.0113173t + 0.01335\left(e^{\frac{t}{100}} - 1\right)\right\}$$

Expressed in absolute temperatures this equation becomes

$$y = 51°51'.4 - \left\{0.0113173T + 0.00087093e^{\frac{T}{100}}\right\}$$

[3] This function is the simplest combination of an algebraic with a transcendental function. The introduction of the exponential series into the equation has the effect of rapidly increasing the slope of the curve near the inversion point. On forming the second and third differential quotients of this function we find that $\frac{d^3y}{dt^3} = \frac{d^2y}{dt^2}$. Now in mechanics the first differential quotient is termed the velocity and the second differential quotient, the acceleration. The product, mass times acceleration, defines the force acting. If we interpret the above differential quotients from this view-point we find that the rate of change in acceleration of angular velocity with temperature at any time is equal to the acceleration (force) itself. This condition implies a force which increases with greatly increasing rapidity as the temperature rises and indicates that at some definite temperature (575° in quartz) the force has reached such a magnitude that the crystal forces can no longer withstand it; a profound change in the internal arrangement results to relieve the stresses set up. Simple inspection of the curve indicates that its rise near the inversion point is so great that such a condition can not continue far above 575°.

It is interesting to note that the exponential function above is similar in form to that suggested by Dr. Adams in the last number of this Journal, p. 469. All such equations reduce on differentiation to the form $\frac{d^3y}{dx^3} = K\frac{d^2y}{dx^2}$ and indicate clearly that the curve they represent can not be expressed by a simple polynomial with positive exponents. The introduction of the exponential function provides more effectively for the extra rapid rise or fall and consequent straightening out of the curve than the addition of an extra term to a polynomial series.

The agreement between the values computed from the first equation and the data of observation is indicated in Table 2.

TABLE 2

| TEMPERATURE | OBSERVED | COMPUTED | DIFFERENCE |
|---|---|---|---|
| 0° | 51° 47′.4 | 51° 47′.4 | 0′.0 |
| 100 | 51 46 .4 | 51 46 .3 | +0 .1 |
| 200 | 51 45 .1 | 51 45 .1 | 0 .0 |
| 300 | 51 43 .8 | 51 43 .8 | 0 .0 |
| 400 | 51 42 .1 | 51 42 .2 | −0 .1 |
| 500 | 51 39 .8 | 51 39 .8 | 0 .0 |
| 550 | 51 38 .0 | 51 37 .9 | +0 .1 |
| 575 | 51 36 .7 | 51 36 .7 | 0 .0 |

A check on these values was obtained from the data on the expansion of quartz parallel to the principal axis as determined by Randall[4] and the specific volumes of quartz kindly furnished me by Dr. Sosman of this Laboratory. These values are listed in Table 3. In Randall's paper the true expansion coefficients only are given. From them the total expansion listed in Table 3 was found by Euler's method of mechanical quadrature.

TABLE 3

| TEMPERATURE | SPECIFIC VOLUME | TOTAL EXPANSION PARALLEL TO AXIS | TOTAL EXPANSION NORMAL TO AXIS | CRYSTAL ANGLE $\rho$ FOR $10\bar{1}1$ CALCULATED | CRYSTAL ANGLE $\rho$ FOR $10\bar{1}1$ OBSERVED | DIFFERENCE |
|---|---|---|---|---|---|---|
| 0° | 0.3772 | 1.00000 | 1.00000 | 51°47′.4 | 51°47′.4 | 0′.0 |
| 100 | 0.3785 | 1.000806 | 1.00132 | 51 46 .5 | 51 46 .4 | +0 .1 |
| 200 | 0.3803 | 1.001744 | 1.00317 | 51 45 .1 | 51 45 .1 | 0 .0 |
| 300 | 0.3821 | 1.002867 | 1.00504 | 51 43 .8 | 51 43 .8 | 0 .0 |
| 400 | 0.3845 | 1.004249 | 1.00752 | 51 42 .0 | 51 42 .1 | −0 .1 |
| 500 | 0.3877 | 1.006072 | 1.01079 | 51 39 .6 | 51 39 .8 | −0 .2 |

The changes in the crystal angle $\rho$ of the unit rhombohedron with temperature as calculated from these data are given in column 5, the observed values in column 6 and the differences in column 7. The agreement between observation and theory is excellent, better in fact than might well have been expected from the data used. Such close agreement should be considered more or less accidental.

[4] Phys. Rev., **20**: 10–37. 1905.

It is of interest to note the similarity in shape between the curves representing the changes in other properties of quartz.[5] These are listed in Table 4 and are represented graphically in figure 2 after reduction to a common unit. From these curves it is evident that whatever it is that produces the changes in quartz as the inversion point is approached, the relative changes produced bear practically linear relations to one another. This applies to crystal angles, total expansion, specific volume, birefringence and circular polarization. The curves representing refractive indices as determined by Rinne and Kolb[6] are, however, somewhat different in shape. No satisfactory explanation of this divergence has yet been found. A redetermination of the refractive indices of quartz at various temperatures is being undertaken in this Laboratory.

TABLE 4

| TEMPERATURE IN DEGREES | CRYSTAL ANGLE ρ OF $10\bar{1}1$ | DIFFERENCE IN PER CENT | TOTAL EXPANSION PARALLEL TO AXIS | DIFFERENCE IN PER CENT | SPECIFIC VOLUME | DIFFERENCE IN PER CENT | BIREFRINGENCE | DIFFERENCE IN PER CENT | EXCESS SPEC. HEAT OF QUARTZ OVER MICROCLINE | DIFFERENCE IN PER CENT |
|---|---|---|---|---|---|---|---|---|---|---|
| | 51° | | 1.00 | | 0.3 | | 0.00 | | 0.0 | |
| 0° | 47′.4 | 0 | 0000 | 0 | 772 | 0 | 910 | 0 | 000 | 0 |
| 100 | 46 .4 | 11.0 | 0806 | 11.1 | 785 | 9.6 | 900 | 9.5 | 053 | 6.4 |
| 200 | 45 .1 | 24.4 | 1744 | 24.0 | 803 | 22.4 | 887 | 21.8 | 123 | 14.9 |
| 300 | 43 .8 | 38.6 | 2867 | 39.6 | 821 | 36.0 | 872 | 36.2 | 223 | 27.0 |
| 400 | 42 .1 | 56.1 | 4249 | 58.6 | 845 | 53.7 | 853 | 54.4 | 366 | 44.4 |
| 500 | 39 .8 | 81.0 | 6072 | 83.8 | 877 | 77.3 | 827 | 79.4 | 598 | 72.5 |
| 550 | 38 .0 | 100.0 | 7250 | 100.0 | 908 | 100.0 | 805 | 100.0 | 825 | 100.0 |

In order to form an idea of the energy relations involved I obtained from Dr. White of this Laboratory the values of his deter-

[5] The equations which represent the changes in the different properties of quartz with temperature are:

Birefringence, $y = 0.00910 - \left\{0.115735t - 0.171195\ \left(e^{\frac{t}{100}} - 1\right)\right\} 10^{-5};$

Specific volume $y = 0.3772 + \left\{0.154944t + 0.202369\ \left(e^{\frac{t}{100}} - 1\right)\right\} 10^{-4};$

Total expansion, in calories per gram, $y = 1 + \left\{0.090812t + 0.0961713\ \left(e^{\frac{t}{100}} - 1\right)\right\} 10^{-4};$

Excess spec. heat, per degree $y = 0.0061302t + 0.0200392\ \left(e^{\frac{t}{100}} - 1\right).$

The constants in these equations were obtained by the least square method from the data of observation.

[6] Neues Jahrbuch für Mineralogie, **2**: 138–158. 1910.

minations of the mean specific heats of quartz at 100°, 300°, 500°, 550°; also of the mean specific heats of two normal silicates, albite and microcline, which do not have low temperature inversion points. From these values the total heats were computed. The specific heats of quartz were consistently higher than those of albite and microcline which behave like other normal silicates in their specific heat values. The differences between the total heats of quartz

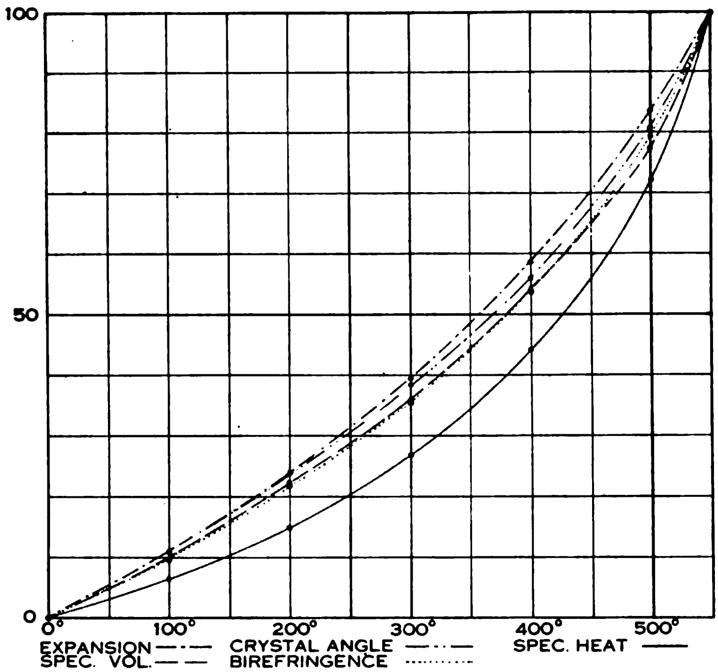


Fig. 2

and microcline for the different temperatures are plotted in figure 2. The general shape of this curve is similar to that representing the change in crystal angles except that its curvature is greater and approaches that of a circular arc. Altho part of this difference in shape may be due to experimental error in the different sets of values yet it is an appreciable difference and may express relations of which we are at present unaware. It is evident, however, that in a general way the relative changes in the crystallographical and optical properties of quartz with temperature follow

the changes in its excess energy content. In calcite the change in crystal angles with temperature is practically linear up to 600°. This indicates that in quartz the excess in energy content represents an internal reaction or equilibrium condition which eventually causes the inversion. It will be of interest to study other minerals, showing inversion points, with respect to their energy content and crystallographical and optical properties at different temperatures; also to ascertain the form of the curves near the melting points.

PALAEONTOLOGY.—*The systematic position of the Crinoid family Plicatocrinidae.* AUSTIN H. CLARK, National Museum.

In the preparation of the section dealing with the Crinoidea in the new edition (1913) of Eastman's translation of Zittel's *Palaeontologie*, Springer and Clark[1] were unable to come to a satisfactory conclusion regarding the proper systematic position of the family Plicatocrinidae (as defined by us including the genera *Plicatocrinus*, *Hyocrinus*, *Gephyrocrinus*, *Thalassocrinus*, *Ptilocrinus* and *Calamocrinus*), which we tentatively placed among the Crinoidea Articulata, just beyond the comatulids, the young of which the species in this family greatly resemble.

The Articulata include all of the other recent crinoids so far discovered and this fact, together with the close resemblance of the species of Plicatocrinidae to the young of the comatulids, was largely responsible for our placing this family here. But the species of the Plicatocrinidae differ from all of the other forms included in the Articulata in a number of most important and fundamental features.

1. The tegmen is entirely covered with a pavement of solid plates.

2. The orals are always present; they are not plane or spherical triangles, as they are in all of the (comparatively few) species of Articulata which possess them, but their edges are turned upwards so that instead of presenting five sharp angles to the mouth they

[1] When this paper was prepared and sent to press Mr. Springer was absent from Washington, but he returned to the city just before its publication. After a discussion of the subject matter he requested me to add a note stating that he is in complete accord with my conclusions as herein expressed.

meet above it in five sharp parallel edges, as do the orals of the stalked young of the macrophreate comatulids.

3. The calyx is more or less asymmetrical; the two posterior radials may be enlarged, as in *Calamocrinus*, or there may be a very small basal just to the right of the anal area, as in *Hyocrinus*. In the young of the comatulids the two posterior radials may be larger than the others, and there is always a radianal, situated more or less to the right hand side of the posterior interradius.

4. The dorsal cup is very large, entirely enclosing the visceral mass dorsally and laterally; this condition is identical with that found in the young of the comatulids, but only occurs in the adults of the Articulata in the highly aberrant *Marsupites*.

5. The plates of the dorsal cup are very thin, entirely lacking the extensive inward calcareous development so characteristic of all the other species of the Articulata; in this the Plicatocrinidae agree with the young of the comatulids, and with the highly aberrant pelagic comatulids *Marsupites* and *Uintacrinus*.

6. Instead of occupying the entire distal edge of the radials as in the Articulata (excepting only the highly aberrant *Marsupites*), the arm bases occupy only a small part, as in the stalked young of the comatulids.

7. There are no infrabasals.

8. There are no pinnules on the arm bases; proximal pinnules are, except in a few very exceptional instances among the comatulids, always present in the Articulata; but they are absent in the young of the comatulids until a considerable size is attained.

9. Tho the pinnules have essentially the same basal structure as those of the Articulata, they are in all ways more generalized, and suggest in many ways ramules or degenerate arm branches rather than perfect pinnules of the Articulata type; in this they resemble the pinnules of the very young comatulids, or of the growing tip of the arm in larger specimens.

10. The apex of the dorsal cup shows a tendency to form a concavity for the reception of the column.

11. The column lacks all trace of the modified columnal known as the proximale, but adds new segments at its summit thruout life; in this respect the column resembles that of the young coma-

tulids before the appearance of the final stem segment, which eventually will come to form the centrodorsal.

12. There are no cirri; the column is attached by a heavy terminal stem plate as in the young of the comatulids.

A few words of explanation regarding the column of the Articulata may not be out of place here. The column of the Articulata (entirely absent in the Comatulida Innatantes, the one suborder of comatulids not represented in the recent seas) is entirely different from that of any other crinoids for, instead of growing continuously thruout life thru the formation of columnals just under the crown, it possesses a definite growth limit at which further increase in the number of columnals abruptly ceases, and the last columnal to be formed becomes attached to the calyx by close suture (usually fusing with the infrabasals), enlarges, and becomes the so-called proximale which is, to all intents and purposes, an apical calyx plate. Immediately below this enlarged columnal or proximale is another more or less modified columnal to which it is attached by a modified close suture, the so-called stem syzygy which, except for a superficial resemblance, has nothing in common with the brachial syzygies.

The typical form of the column in the Articulata is seen in the young of the comatulids at the time of the formation of the centrodorsal; but this typical form persists in the adults only in the genus *Thiolliericrinus*, and in the family Phrynocrinidae. In such types as the Apiocrinidae the proximale is so enormously enlarged that it involves with itself in this process a considerable number of the columnals beneath it, so that a cone shaped series of enlarged columnals is formed, each of which is a reduplication, progressively less perfect, of the proximale just beneath the calyx. Essentially the same state of affairs is seen in the Bourgueticrinidae, especially in the recent genus *Ilycrinus*. In the comatulids (excepting in the Innatantes, which never possess one) the column is discarded at the stem syzygy between the proximale and the columnal just beneath it.

In the young pentacrinite the proximale is formed exactly as in the young comatulid; but the great excess of column growth induces the formation of new columnals between the proximale and

the calyx before the proximale has time to become attached; the proximale therefore becomes pushed away from the calyx, but exactly as in the case of the comatulids, cirri are protruded from it, and it becomes united to the columnal just below it by a stem syzygy, these two columnals now forming what is known as a nodal and an infranodal, the nodal (with the cirri) being in origin a true proximale, and the infranodal the columnal just beneath the true proximale. Following the formation of this first nodal the pentacrinite proceeds to grow an entirely new column, of which the first nodal represents the terminal stem plate; this second column grows to a definite length, and then the same nodal forming process is repeated. Each pentacrinite nodal with the series of internodals beneath it, therefore, is morphologically the equivalent of the entire column in such types as the Apiocrinidae, Phrynocrinidae, or the comatulids.

In the adult pentacrinites only nodals are formed just beneath the calyx, so that here we have a series of reduplicated proximales, just as in the Apiocrinidae; but none of these nodals become attached to the calyx, for they are constantly being pushed away from the calyx by the formation of new nodals. At a little distance from the calyx intercalated columnals begin to appear between them, with the nearest of which they always unite themselves by syzygy, so that at a somewhat greater distance from the crown the nodals (proximales), united by syzygy to the infranodals, with which they form syzygial pairs, become regularly spaced, forming the typical pentacrinite column as we commonly find it.

In the bourgueticrinoid type of column any two of the columnals may be united by stem syzygy; these double columnals are rare in the distal portion of the column, but increase in frequency toward the crown. Each of these syzygially united pairs of columnals represents an effort to form a proximale which, thru excessive stem growth, has been thrust away from the calyx exactly as in the case of the pentacrinites. In addition to these there is just under the crown a definite series of proximales, corresponding to the continuously growing and indefinite series found in the pentacrinites. To emphasize the essential similarity of the

columns of the pentacrinites and of the Bourgueticrinidae it may be mentioned that the earliest nodals in the young pentacrinite column resemble far more the syzygially united columns in the bourgueticrinoid column than they do the nodals of the adult, for they are much elongated, and the cirri are usually defective, three, two, or sometimes only one, in number.

It is evident that the structure of the Plicatocrinidae in all of its details corresponds very closely to that of the young comatulids before the appearance of the columnal which is eventually to form the centrodorsal; it is also evident that this family can scarcely find a logical position among the Articulata, from all of the other forms in which it differs so radically.

The order Inadunata of Wachsmuth and Springer includes Crinoidea in which the arms are free above the radials; the dorsal cup is limited to radials, basals, infrabasals (when present) and anal plates; no interradials nor interbrachials occur except at the posterior (anal) side, and the brachials are never incorporated in the cup; all the plates of the cup are united by close suture; the mouth is subtegminal; the column is circular in section (with very rare exceptions), without a proximale.

It is at once evident that the Plicatocrinidae agree with the members of this order far better than they do with those of the Articulata, differing only in a lack of a distinct differentiation of the posterior area, and in the possession of open food grooves and an open mouth. But in the Encrinidae, which are referred to this order, the posterior area is in no way different from the others, while in at least three of the recent genera of the Plicatocrinidae it is not quite the same, so that this difference is very slight. In many of the fossil Inadunata we do not know the disk; while among recent types the genera of the Plicatocrinidae have the deepest food grooves and the nearest approach to a subtegminal mouth; it may be that in reality this apparent difference is nonexistent.

A rapid survey of the various families of the Inadunata— in the suborder Larviformia the Stephanocrinidae, Pisocrinidae, Haplocrinidae, Allegecrinidae, Synbathocrinidae and Cupressocrinidae, and in the suborder Fistulata the Hybocrinidae, Heterocrinidae,

Anomalocrinidae, Cremacrinidae, Catillocrinidae, Belemnocrinidae, Dendrocrinidae, Crotalocrinidae, Cyathocrinidae, Botryocrinidae and Poteriocrinidae—cannot fail to give the impression that there is certainly more than a superficial similarity between these types and the Plicatocrinidae. As an interesting point it may be noticed that the systematic interrelationships within the family order Inadunata are decidedly heterogeneous, and the same character is clearly reflected within the family Plicatocrinidae.

While the Plicatocrinidae, broadly speaking, may be said to agree perfectly with these families collectively—that is to say the characters presented by the component species may all be matched in the order Inadunata and in no other order—the family cannot definitely be assigned to any certain position. Therefore the most logical position for the Plicatocrinidae appears to me to be within the order Inadunata, at the end of the series of families, beyond the Poteriocrinidae.

Long ago (1899) Dr. F. A. Bather reached the conclusion that the Plicatocrinidae (which he divided into Plicatocrinidae and the Hyocrinidae) were really inadunate forms, and he accordingly included them in the Inadunata, which he considered as comprising the Hybocrinidae, the Stephanocrinidae, the Heterocrinidae, the Calceocrinidae, the Pisocrinidae, the Catillocrinidae, the Zophocrinidae, the Haplocrinidae, the Allegecrinidae, the Synbathocrinidae, the Belemnocrinidae, the Plicatocrinidae, the Hyocrinidae and the Saccocomidae.

Of the four great orders of crinoids, two, the Camerata and the Flexibilia, range from the Ordovician thru the Carboniferous. The Inadunata began in the Ordovician, one (possibly two) families persisting to the Permian, and one to the Trias, in which horizon the stalked pentacrinites were already developed. The Articulata began, so far as we can ascertain, in the Trias, and all of the fossil types (excepting only the Thiolliericrinidae and the Eugeniacrinidae) persist in the recent seas. It is thus not at all surprising that we should find in the recent seas, in addition to the dominant Articulata, a remnant of the Inadunata.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

GEODESY.—*Triangulation along the west coast of Florida.* CLARENCE H. SWICK. Special Publication No. 16, U. S. Coast and Geodetic Survey. 1913.

This publication gives the results of triangulation done by the Coast and Geodetic Survey and the Engineer Corps, U. S. Army, on the west coast of Florida from Cape Sable to the Alabama boundary and from the inland town of Gainesville to the coast at Cedar Keys. This, together with Appendix No. 6, U. S. Coast and Geodetic Survey Report for 1911, gives all the available triangulation data for the State of Florida.

Altho only of tertiary accuracy, this triangulation has a great practical value in that it furnishes to the geographer and to the engineer the geographic positions of more than 1150 points all correlated on one geodetic datum. The observations involved extend over a period of more than sixty years and some of the stations are lost, but in the bays and harbors and at other important places along the coast new triangulation supplements the old, and, as a rule, the more recent points are permanently marked and may be recovered without difficulty. There is given the latitude and longitude of each station and the azimuth of each line observed over; also all available descriptions of the location and marking of the stations. A series of sketches and an index of stations make it possible to find readily the data for any point or locality.

C. H. SWICK.

GEOPHYSICS.—*Note on the temperature in the deep boring at Findlay, Ohio.* JOHN JOHNSTON. Am. Jour. Sci., (4) **36**: 131–134. 1913.

A record of a series of temperature observations made in a hole drilled to a depth of 3000 feet in the neighborhood of Findlay. The temperature gradient in the sedimentary rocks at horizons between 1100 and 2600 feet proved to be about 0°.41C. per 100 feet, which is smaller than what has been considered the common average value of this gradient.

J. J.

PHYSICS.—*La mesure des températures élevées par le thermomètre à gaz.* ARTHUR L. DAY and R. B. SOSMAN. J. d. Physique (5), **2**: 727–749; 831–844; 899–911. 1912.

A translation into French, by Prof. P. Chappuis, of "High Temperature Gas Thermometry" (Publication of the Carnegie Institution of Washington, No. 157, 1911). The material has been somewhat condensed and rarranged, and the later work on the revision of the lower portion of the high temperature scale and on the boiling point of sulfur ("The nitrogen thermometer scale from 300° to 630° with a direct determination of the boiling-point of sulfur. Am. J. Sci. (4), **33**: 517–533. 1912) added. A. L. D.

ELECTRICITY.—*The analysis of alternating current waves by the method of Fourier, with special reference to methods of facilitating the computations.* F. W. GROVER. Scientific paper 203, Bull. Bureau of Standards. 1913.

The natural method for the analysis of alternating electromotive force and current curves is by means of the classic equations of Fourier, but on account of the labor involved, recourse is often had to graphical or approximate methods. Runge has shown that, by grouping similar terms, the number of terms, which need to be calculated in the Fourier method, may be materially reduced, but his work does not seem to be generally known. The present paper has for its purpose the presentation of the method of Runge in a form which shall be of especial service in making numerical computations. By systematic arrangement of the work, and by use of tables given, the labor of calculation has been very considerably reduced. Examples of the analysis of actual, experimentally obtained curves are given, which illustrate the methods of computation, and the practical applications which may be made of the results of the analyses. F. W. G.

PHYSICAL CHEMISTRY.—*The physical chemistry of Seger cones.* ROBERT B. SOSMAN. Trans. Am. Ceramic Soc., **15**: 482–498. 1913.

The relation of certain simple principles of physical chemistry to the behavior of the Seger pyrometric cones, which are widely used in the ceramic industry for the indication of heat effects in the kilns, was illustrated by experiments and charts. The high temperature cones Nos. 28 to 42 form a simple two-component series composed of alumina and silica. Their behavior agrees well with the known properties of this system, taking into account the three retarding influences: (1) lack of initial homogeneity, (2) slow rate of fusion of silica, and (3) high

viscosity of the melt. Cones 5 to 27 are made up of four oxides. It is possible to discuss them, however, as a three-component system of orthoclase, calcium silicate, and aluminum silicate, with excess silica as a relatively inactive addition. In this system, as in the foregoing, the control exercised by the low-melting eutectics upon the indications of the cones is well brought out. R. B. S.

GEOLOGY.—*Are quantitative physico-chemical studies of rocks practicable?* Arthur L. Day. Comptes Rendus Congrès International Géologique XI, Stockholm, 1910. Vol. II, pp. 965–967.

An address before the Section on Mineralogy and Petrography of the Eleventh International Congress of Geologists, in which an effort was made to show by reference to recent laboratory studies of simple mineral relations, using physico-chemical methods, that these methods must eventually find application in the study of the very complicated mineral systems (the igneous rocks) also. A. L. D.

GEOLOGY.—*The volcanoes and rocks of Pantelleria.* Henry S. Washington. J. Geol., **21**: 653–670. 1913.

Ths island of Pantelleria was studied in September, 1905, and the paper describes both the volcanic structure and the petrography of the very interesting lavas.

Pantelleria (which lies about half-way between Tunis and Malta) is entirely volcanic. It consists of an early, large cone, composed of trachytes and pantellerites. After a large explosive caldera was formed in this, a second volcanic phase began, consisting of the building up of a trachyte core within the caldera. Later this was faulted and a large block tilted down, smaller cones and flows of glassy pantellerite being poured out about this. Volcanism ceased with the formation of many small basaltic cones on the flanks of the earliest cone.

The important lavas are described in great detail, seventeen complete chemical analyses having been made. The trachytes and pantellerites are interesting because they carry abundantly well developed crystal of soda-microcline, an unusual feldspar, the crystals of which are to be investigated optically and chemically later. The latter rocks are also noteworthy for their content in the rare, triclinic, sodic amphibole, cossyrite. The basalts are of a common type, but their occurrence here in connection with such highly sodic rocks is of interest.

The relations of the lavas to the volcanism were examined, and there is a probable connection between the successive changes in the magma and the phases of volcanicity, a feature apparently here recognized for

the first time. Such a connection would be of great volcanologic importance, and as there is evidence of its obtaining at other volcanic centers, it will form the subject of future investigation.

The analyses of these rocks made by the author show that all the earlier analyses, which have been very often cited, are subject to serious analytical errors. The paper closes with a comparison of the Pantellerian lavas with those of other regions. H. S. W.

PETROLOGY.—*The index ellipsoid (optical indicatrix) in petrographic microscope work.* FRED. EUGENE WRIGHT. Am. Jour. Sci. (4), **35**: 133–138. 1913.

In this paper the importance of presenting the subject of microscopical petrography consistently from the viewpoint of the index ellipsoid as applied to wave-front normals is emphasized. The various optical properties employed in practical petrographic microscope work can be best described and explained systematically, by means of the index ellipsoid. The use of the so-called "axes of elasticity," $\mathfrak{a}$, $\mathfrak{b}$, $\mathfrak{c}$, or X, Y, Z, in this connection is confusing and only adds to the difficulties encountered by the observer in mastering the subject. They should accordingly be abandoned and the French usage of naming the principal axes of the index ellipsoid, $\alpha$, $\beta$, $\gamma$ (or $n_p$, $n_m$, $n_g$) adopted. This applies in particular to the different modes now in vogue for expressing extinction angles. For a given crystal face an extinction angle is simply the angle between a definite crystallographic direction on the face and one of the axes, $\alpha'$ or $\gamma'$, of its optic ellipse, and this fact should be indicated in the expression for the extinction angle. To introduce "axes of elasticity" ($\mathfrak{a}'$, $\mathfrak{c}'$, or X′, Z′) in this connection is not only needless but less direct, as it introduces entirely new conceptions which, experience has shown, only tend to bewilder the student. F. E. W.

MINERALOGY.—*Two varieties of calciovolborthite(?) from Eastern Utah.* W. F. HILLEBRAND and H. E. MERWIN. Am. Jour. Sci. (4), **35**: 441–445. 1913.

From chemical studies, two minerals from Paradox Valley, Colorado, are considered to be varieties of calciovolborthite. In the absence of optical data concerning the original mineral, the following optical properties, determined from one of these varieties, are assigned to calciovolborthite. Color, yellow-green, with no distince pleochroism; biaxial, with strong inclined dispersion; optically negative for blue and positive for red; $\alpha_{Na} = 2.01$, $\beta_{Na} = 2.05$, $\gamma_{Na} = 2.10$. The optical properties give evidence of monoclinic symmetry. W. F. H.

CRYSTALLOGRAPHY.—*The simultaneous crystallization of calci e and certain sulfides of iron, copper and zinc.* H. E. MERWIN. Am. Jour. Sci. (4). 1913.

The study of three occurrences of the sulfides of ·ron and zinc has established the certainty of the deposition of marcasite and the strong probability of the deposition of wurtzite contemporaneously with calcite. The marcasite is d·finitely oriented with regard o the calcite and also to accompanying pyrite. A close similarity between the crystallogra hic elements of pyrite and marcasite is shown. H. E. M.

BOTANY. *Le fruit mûr et les jeunes semis de l'Aeglopsis Chevalieri.* WALTER T. SWINGLE. Bull. de la Soc. bot. de France, **60**: 406–409, Fig. A, No. 5, séances de mai-juin, Sept. 15, 1913.

As a supplement to the original description of *Aeglopsis Chevalieri*, the structure of the ripe fruit and the mode of germination are described in detail. The shell of the fruit is less woody than that of the other genera of the hard-shelled group of citrous fruits with the exception of Chaetospermum. The fruits are slightly pyriform at the base and often show a low protuberance at the apex. The peel is brilliant orange-brown. The membrane separating the cells is very thin, making them triangular in shape. They are filled with large flattened seeds immersed in a sticky transparent amber-colored aromatic fluid. The shell of the fruit is made up of two layers, the brilliantly colored hardened glandular skin, and a woody layer, on the inside of which there are numerous small glands. It is thought that these may secrete the sticky fluid surrounding the seeds. A seven-celled fruit is figured in cross and longitudinal section.

The seeds germinate quickly and the cotyledons, altho they turn green remain underground but near the surface. The first pair of leaves are opposite, sessile and cordiform. There is also a second pair of opposite leaves which are distinctly petiolate. This plant differs from all others of the tribe *Citreae* hitherto studied in having this second pair of opposite leaves. MAUDE KELLERMAN.

ZOOLOGY.—*A Revision of the crinoid family Mariametridæ.* AUSTIN HOBART CLARK. Proceedings of the Biological Society of Washington, **26**: 141–154. 1913.

The family Mariametridæ, as here revised, includes six genera, *Pontiometra, Oxymetra, Liparometra* (nov.), *Lamprometra* (nov.), *Dichrometra* and *Mariametra*, to which forty-nine described species are assigned. The range of each genus is given, together with the reference to the original description. A key showing the differential characters of the genera is included. A. H. C.

# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE WASHINGTON ACADEMY OF SCIENCES

The 86th meeting of the Washington Academy of Sciences, a joint meeting with the Anthropological Society of Washington, was held in the Auditorium of the New National Museum, on Monday evening, October 20, 1913.

His Serene Highness, the PRINCE OF MONACO, gave a lecture on *Researches in oceanography and anthropology*, illustrated with lantern slides and motion pictures.

The various ingenious devices used in the manifold branches of oceanography were described by the speaker, and their operation on his own yacht clearly illustrated by a number of moving pictures—pictures that showed not only how the work was done, but also the alertness and the zest of the investigator to learn new facts.

The remarks on anthropology were confined chiefly to an account of the reasons for, and uses to be made of, an Anthropological Institute which, thru the speaker's generosity, is being established in Paris.

W. J. HUMPHREYS, *Recording Secretary.*

## THE CHEMICAL SOCIETY

The 228th meeting was held in Baltimore, at the Physical Laboratory of the Johns Hopkins University, on May 17, 1913. The meeting was called to order at 8.25 p.m. by W. W. Randall. The following papers were presented:

*The theory and application of the selenium cell*, by A. H. PFUND. Discussion by Sidell, Cox, Acree and Randall.

*The absorption spectra of solutions* (Illustrated), by J. SAM GUY.

C. P. VAN GUNDY, *Secretary* pro tem.

The 229 meeting was held at the Cosmos Club, on October 9, 1913. The following papers were read:

*Equilibrium in the system alkali carbonate-silica*, PAUL NIGGLI of the Geophysical Laboratory. Presented by JOHN JOHNSTON. The system $M_2O$-$SiO_2$-$CO_2$ has been experimentally investigated for the alkali metals sodium, potassium, and lithium. The changes in weight were determined of mixtures of alkali carbonate and silica, under one atmosphere of carbon dioxide, at various accurately measured temperatures. The paper appeared in full in the November *Journal of the American Chemical Society*. The paper was discussed briefly by Foster and Johnston.

*New crystalline silicates of potassium and sodium* by G. W. MOREY of the Geophysical Laboratory. The bomb used for heating mixtures in the presence of water at high temperatures was described and shown. The properties of the new silicates and silicate-water melts which have been prepared were then briefly covered, and samples were shown. The paper will appear in full in the *Journal of the American Chemical Society*.

Reports from the Rochester meeting of the general Society were made as follows: C. L. Parsons, on the proceedings of the Council; R. C. Wells, on the physico-chemical papers; I. K. Phelps, on biochemistry; J. A. LeClerc, on agricultural chemistry, papers on hygiene, and excursions; M. X. Sullivan, on various papers not mentioned in the other reports; Hillebrand and Bigelow, on the Smoker; Walker, on the coal analysis discussion; and Cameron, on the fertilizer section. The question of agreement on analytical methods, raised by Cameron, was discussed by Hillebrand, who pointed out the need of testing the homogeneity of standard samples before sending them out.

The question of the absorption of the *American Chemical Journal* by the American Chemical Society was discussed at some length. The meeting decided to take no action in opposition to the decisions of the Council and Directors of the general Society.

The 230th meeting was held at the Cosmos Club, on November 13, 1913. The President appointed the following committee to represent the Society at the McGee Commemorative Meeting on December 5. F. W. Clerke, W. Blum, F. K. Cameron, W. F. Hillebrand and D. T. Day.

The election of officers for 1914 resulted as follows: *President*, M. X. SULLIVAN, Bureau of Soils; *First Vice-President*, C. L. ALSBERG, Bureau of Chemistry; *Second Vice-President*, H. H. BUNZEL, Bureau of Plant Industry; *Secretary*, R. B. SOSMAN, the Geophysical Laboratory; *Treasurer*, F. P. DEWEY, the Mint; *Councilors*, J. A. LECLERC, L. M. TOLMAN and P. H. WALKER of Bureau of Chemistry, and S. F. ACREE of Johns Hopkins University; *Executive Committee*, E. C. MCKELVY of Bureau of Standards, R. C. WELLS of Geological Survey, J. JOHNSTON of Geophysical Laboratory and E. W. BOUGHTON of Bureau of Chemistry.

ROBERT B. SOSMAN, *Secretary*.

## THE BOTANICAL SOCIETY OF WASHINGTON

The 13th annual meeting of the Botanical Society of Washington was held at the Bureau of Plant Industry on October 17, 1913, with seventeen members present. The customary reports were presented and approved and the following officers elected for the ensuing year: *President*, C. L. SHEAR; *Vice-President*, A. S. HITCHCOCK; *Recording Secretary*, C. E. CHAMBLISS; *Corresponding Secretary*, P. L. RICKER; *Treasurer*, H. H. BARTLETT. Mr. F. L. LEWTON was nominated as Vice-President from the Society for the Washington Academy of Sciences.

The 90th regular meeting of the Botanical Society of Washington was held on October 6, 1913, at the Cosmos Club with forty-two members and seventeen guests present, including the following distinguished European botanists: Frau Dr. BROCKMANN-JEROSCH, Zürich; Dr. EDWARD RÜBEL, Zürich; Prof. CARL SCHRÖTER, Zürich; Prof. C. VON TUBEUF, Münich.

The program consisted of brief informal remarks, as follows:

President STOCKBERGER: An address of welcome to the guests of the Society.

Mr. WALTER T. SWINGLE: *Citrus plants of the world and their importance and use in connection with citrus culture and citrus breeding.*

Prof. C. VON TUBEUF: *A brief summary of the results of twenty years' work with the mistletoe.* (Translated by Prof. Schröter).

Mr. DAVID FAIRCHILD: *Plant introduction work of the Bureau of Plant Industry.*

Prof. CARL SCHRÖTER: *Impressions received during the American International Phyteographic excursion.*

Mr. CARL KELLERMAN: *Nodule production and nitrogen fixation by plants other than leguminosae.*

Mr. HAVEN METCALF: *The chestnut blight disease.*

Mr. W. E. SAFFORD: *Photographs of bullthorn acacias.*

The 91st regular meeting of the Botanical Society of Washington was held on November 4, 1913, at the Cosmos Club with forty-six members and five guests present.

Dr. HARRY B. HUMPHREY and Messrs G. C. HUSMANN and K. J. J. LOTSY were elected to membership.

The action of the retiring Executive Committee relative to the giving of a dinner in honor of the seventieth birthday of Dr. EDWARD L. GREENE was called to the attention of the Society by the President and a committee was appointed to arrange the details.

The following scientific program was presented:

*Abbreviations used in the citation of botanical literature.* Prof. A. S. HITCHCOCK. The speaker pointed out the different methods used for abbreviating citations, the extreme contraction on the one hand, such as "O B Z" (Oesterreichische Botanische Zeitschrift), and on the other the elaborated citations used by some authors in the Pflanzenreich. Abbreviations should be brief as possible consistent with clearness, but should follow a definite system. The speaker described the system followed in abbreviating citations used in the Contributions from the National Herbarium. The record of authorized abbreviations of authors and titles is indexed in a card catalog. Authors consult this record when preparing manuscript for publication, thus aiding the editor to secure uniformity.

*Non-parasitic foliage injury.* Mr. CARL P. HARTLEY. Notes were given on the effects of drouth and storm on leaves of ornamental trees at Washington, D. C., for the past season. June and July were hot and dry, with but 35 per cent of normal rainfall. Norway maple, es-

pecially in street planting, suffered most from drouth, the margins of leaves being killed; in the worst cases whole leaves except parts immediately adjoining the veins died. Most other trees, including *Acer rubrum*, escaped serious leaf injury. A northeast storm with hail and a 66-mile wind at the end of July injured many species, especially sugar maple and American basswood. The storm injury to maple resulted in the death of part of the leaf at the margin and between the veins, without laceration or other external indication of mechanical injury. These storm-injured maple-leaves could be distinguished from those hurt by drouth only by their limitation to parts of trees especially exposed to the storm.

*Pitfalls in plant pathology.* Dr. H. W. Wollenweber. A revision of the hundreds of species of Fusarium in literature has led the speaker to believe that the genus Fusarium contains only 30 to 50 different forms. A sharp criticism was given to mycologists who send unreliable specimens to the international "Pilzcentrale" in Amsterdam. Many errors are caused by the earlier opinion that Fusaria as a rule are adapted to one particular host. Upon receiving a request for a particular wound-parasitic Fusarium even the author of that species is liable to make the following mistake. He isolates from a diseased specimen a fungus, which he sends to the inquirer when it has produced sickle shaped spores which he thinks belong to species previously described by him. Upon a second request perhaps a year later he would isolate similarly from another specimen of the same host presuming to obtain the same fungus. The speaker by chance checked up the strains sent under the same name to three different places at various time by the same author and found two different species. Careful reference to the source and the method of isolations and determination are required to eliminate mistakes of this sort.

If one is unfamiliar with the method used to develop sporodochia with normal spores he might consider a subnormal spore as normal. This leads to another pitfall, where diagnoses of the same species disagree and the subnormal fungus is described as new. An example of this kind is *F. trichothecioides* Wr., wound parasite of the potato, a fungus the early stage of which is described as *F. tuberivorum* by Wilcox and Link.

*Nectria ipomoeae* Halsted is mentioned as an example of a species furnishing many pitfalls. This is a cosmopolitan saprophytic ascomycete which crosses the path of various specialists. This fungus is called *Nectria ipomoeae* when isolated from Ipomoea, *N. coffeicola* when from Coffea, *N. cancri*, when from canker spots of Theobroma, *N. vandae* when from Vanda.

*Nectria discophora* Mont. has been four times described as a new species by Paul Hennings, as pointed out by v. Höhnel and Weese, simply because it looked different when collected from various hosts in different stages of its development. In pure culture all these stages could be easily imitated by special treatment and the mistakes once discovered lead to a remarkable simplification of the nomenclature.

The perfect form has been obtained from various fungi with Fusaria-like spore forms. They belong to such genera as Gibberella, Nectria, Hypomyces, Calonectria and Neocosmospora. But the conidia of these ascomycetes have not sufficient relationship to Fusaria without known perfect form to justify identification with any species of Fusarium sections, such as *elegans*, *discolor*, *martiella*, *roseum* and *gibbosum*.

In neglecting such facts we would be exposed to a pitfall in the following case: *Fusarium culmorum* W. G. Smith (*F. rubiginosum* App. & Wr.) has conidia looking so much like small conidia of *Gibberella Saubinetti* (Mont.) Sacc. that they seem to be identical. The former, however, develops chlamydospores and no perfect form, the latter no chlamydospores but the perfect form under culture conditions. If we overlook this we may conclude after having proved one strain to have *Gibberella perithecia*, that we also have proved *F. culmorum* to be a Gibberella. Literature is rich with such errors.

*Sections of a fossil wood from asphalt lake near Los Angeles, Cal.* Dr. ALBERT MANN. Thin sections of the petrified wood were exhibited under a microscope which showed fungus hyphae. Brief notes were given as to the apparent method of the growth of the fungus and the possible identification of the tree was discussed.

P. L. RICKER, *Corresponding Secretary.*

## THE BIOLOGICAL SOCIETY OF WASHINGTON

The 414th regular meeting was held at the Cosmos Club on October 18, 1913, with former President L. O. Howard in the chair and 61 persons present.

The program consisted of three communications:

*The Federal migratory bird regulations and their assistance in the conservation of bird life in America:* T. S. PALMER. The speaker outlined briefly the history of the Weeks-McLean Bill, approved March 4, 1913, and of the adoption of regulations for its enforcement which have been promulgated by the Department of Agriculture under proclamation of the President dated October 1, 1913. Maps of the winter and breeding ranges of some of the species of birds affected were shown, together with another showing the division of the country into two zones. Reasons were given for the exceptions in certain States to the general closed season. In general the beneficial effects upon the bird life of the country expected as a result of the enforcement of the Federal law were pointed out. Hugh Smith and Col. Joseph H. Acklen took part in the discussion which followed.

*The breeding of the loggerhead turtle:* W. P. HAY. The communication was accompanied by lantern slides. It was an account of observations of the habits and reproduction of the diamond-backed terrapin and the loggerhead turtle made at Beaufort, North Carolina. This place is near the northern limit of the distribution of the loggerhead turtle and the speaker was of the opinion that normally in this latitude few of the eggs of the species are left to hatch and that the young from those that may hatch all perish with the first cold weather.

*The first year's results in breeding some Bahama shells (Cerion) on the Florida Keys:* Paul Bartsch. A former communication by the speaker gave an account of the transfer of two races of *Cerion* from the Bahamas to various Florida Keys. The present paper was an account of observations of the condition of the new colonies at the end of the first year. In general they have prospered and in several localities have reproduced young.

The 515th meeting was held at the Cosmos Club on November 1, 1913, with President E. W. Nelson in the chair and about 50 members present.

Under the heading *Brief notes and exhibition of specimens*, C. Dwight Marsh related an observation in Montana of a noise made by a bull snake (*Pituophis sayi*) which was in close imitation of that made by a rattlesnake. The sounds were made by the respiratory organs and were observed by a number of persons.

REGULAR PROGRAM

A. D. Hopkins spoke of *Depredations by forest insects and their control.* He gave a brief historical sketch of early insect invasions of forests and of the means adopted to combat the pests. The greater part of the paper was devoted to depredations of which the author had personal knowledge. The efficacy of modern methods was pointed out, especially the control work undertaken by the Bureau of Entomology in collaboration with the United States Forest Service. These have been generally adopted by large private holders of timber lands and much saving of valuable timber has resulted.

Paul Bartsch gave an account of the results of dredging for mollusks at Chincoteague, Virginia. In two days collecting eleven new species were found. The speaker gave an account of some personal experiences and observations on the island. He was followed by W. P. Hay, who also spoke of his experiences during a visit to Chincoteague and gave some interesting historical notes of the place.

D. E. Lantz, *Recording Secretary.*

## THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At a special meeting of the Anthropological Society on November 4, 1913, Dr. John R. Swanton read a paper entitled *The Indian village.* Dr. Swanton stated that while it is a common notion that country life preceded urban life this view is hardly correct, urban life in its germs going back probably almost as far as man himself. He then took up the various factors tending to produce the village, determine its character, and subsequenty knit it together. These he found to be of three orders, material, social and religious. Among the first he enumerated material available for the construction of houses, position with reference to the food supply and fresh water, and occasionally also position with reference to the sun. Among social factors he treated

trade, desire for exchange of ideas, need of mutual protection and relationship, especially in the peculiar form it assumed under totemism. Finally the growth of a village or town cult was traced from the practical independence of shamanism pure and simple to the complete town ritual, sometimes directly, sometimes thru the fusion of clan ceremonies, and sometimes thru the rituals of religious or other societies. These factors were illustrated by reference to the tribes of the north Pacific coast and the gulf area. A possible evolution was suggested in three stages, first the haphazard collection of hunters, fishers, or perhaps agriculturalists, in a certain spot; second the development of social relations among them, particularly thru intermarriage, and thirdly a religious seal or stamp of unity, tho it was not the writer's intention to set this up as a hard and fast process of evolution. It was noted that totemic clans among some tribes might have been evolved in a similar manner. In conclusion a short comparison was made between the Indian village and the modern city, attention being called to the fact that in the latter the most important determining factor is trade, while in the former relationship, religious observances, and to some extent motives of protection were much more prominent.

The subject was discussed at some length by Mr. J. N. B. HEWITT, who confined his remarks to the village in the social organization of the Iroquois. The basis of the social organization was actual or fictitious blood kinship traced thru the mother. The cohesiveness of the several units was obtained thru the ties of duty and privilege subsisting between clans united by the marriage of their sons and daughters. The clans were organized into two brotherhoods of clans, one of which represented the masculine and the other, the feminine, in nature. This division was maintained in all public meetings. The one side was therefore called the "father side," and the other, the "child side," which of course was the "mother side." Strong lines of actual or artificial kinship and cleavage existed between these two groups. The clans's totems have no especial religious significance at present, that is, there are no ceremonies in honor of them. That there were such in early times is quite possible. The decadence of the worship of the clan totem was probably due to the unification of the clan government into that of the tribe, and later, of the tribe into that of the confederation. The great influence of the council of women, composed of mothers only, in the affairs of the village and tribe and confederation was emphasized, and illustrated by the effectiveness with which they could stop or prevent a war. They needed only to forbid their sons to engage in warlike activity under penalty of becoming outlaws to the tribe and confederation. The gradual adoption of the Tuscarora tribe of North Carolina by the Iroquois League on motion of the Oneidas as their sponsors was described, the Tuscaroras being first regarded as infants, then as boys who were not allowed to take part in the wars and councils of the League, and then, finally, as warriors having their chiefs to represent them in the Federal Council of the League.

DANIEL FOLKMAR, *Secretary.*

## ANNOUNCEMENT OF MEETINGS

The Washington Academy of Sciences will hold a joint meeting with the Philosophical Society on December 4 at 8.15 p.m., in the Cosmos Club Assembly Hall. Prof. JEAN PERRIN, Professor of Physical Chem istry at the University of Paris will address the Academy on *Brownian movement and molecular reality.*

## NINETEENTH INTERNATIONAL CONGRESS OF AMERICANISTS, WASHINGTON, D. C., OCTOBER 5 TO OCTOBER 10, 1914

*Preliminary notice*

Pursuant to arrangements made at the Eighteenth International Congress of Americanists, in London, 1912, the Nineteenth Congress will meet in America in 1914 in two Sessions, the first at Washington, D. C., and the second at La Paz, Bolivia.

The Session at Washington will be held under the auspices of the Smithsonian Institution, in coöperation with the George Washington University, Georgetown University, the Catholic University of America, the Anthropological Society of Washington, and the Washington Society of the Archaeological Institute of America.

During the Session an excursion will be made to the highly interesting aboriginal quarry and workshop at Piney Branch, D. C.; and following the Congress it is expected that two excursions will be arranged, one to Ohio for the examination of ancient mounds, the other to New Mexico for the study of ancient ruined pueblos and cliff-dwellings, as well as of the present Pueblo Indians in their native environment.

To avoid delay in announcements, and to facilitate the organization of the Session, those who desire to become members are urged to communicate as soon as practicable with the Secretary, giving the titles of papers which they wish to present before the Congress, together with a brief summary of each.

ALEŠ HRDLIČKA, *Secretary,*
U. S. National Museum,
Washington, D. C.

THE PROCEEDINGS

OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str., Berlin.

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VOL. III. No. 21

DECEMBER 19, 1913.

# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES



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*Scope.*—The JOURNAL is a medium for the publication of original papers and is a record of scientific work in Washington. It accepts for publication (1) brief papers written or communicated by resident or non-resident members of the Academy; (2) abstracts of current scientific literature published in or emanating from Washington; (3) proceedings and programs of the affiliated societies; and (4) notes of events connected with the scientific life of Washington.

*Manuscripts* may be sent to any member of the Board of Editors and must be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. Footnote references should be complete, including year of publication.

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THE WAVERLY PRESS
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# JOURNAL

OF THE

# WASHINGTON ACADEMY OF SCIENCES

VOL. III DECEMBER 19, 1913 No. 21

TERRESTRIAL MAGNETISM.—*Preliminary results of a first analysis of the sun's general magnetic field.*[1] L. A. BAUER, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

The question whether the sun, like the earth, is surrounded by a magnetic field, received renewed interest from Hale's certain detection in 1908 of magnetic fields in sun-spots, by means of the effect of magnetism on light discovered by Zeeman in 1896. Previous investigators had shown that for a direct magnetic effect attributable to the sun to be readily measurable on the earth, the sun's magnetic moment would have to reach a very large figure. Accordingly our surmises hitherto have had to be confined exclusively to certain phenomena exhibited by the coronal streamers and motion of solar prominences, and by polar lights and magnetic perturbations.

It is a source of extreme satisfaction, therefore, that the means were given Hale to institute a *direct* attack and undertake the systematic detection of a possible general solar magnetic field, employing the same method which had proved successful in the case of sun-spots. As the probable field-intensity *now* was on the order of about one-tenth to one-hundredth of that encountered in the spots, the instrumental difficulties seemed almost insuperable. The observed displacements of the spectrum lines, to be ascribed to the sun's general magnetic field, are, in fact, found to be so small that but for the superior instrumental appli-

[1] Presented before the Philosophical Society of Washington, November 22, 1913. To be published more fully in J. Terr. Mag. and Atmos. Elec., **19**. 1914.

ances and refined methods employed, they would have been regarded as falling within the limits of error of spectroscopic work. After a very laborious investigation extending over several years, in which various persons took part, and instrumental appliances were employed such as are only to be had at the Mount Wilson Observatory, Hale felt justified in making some announcement of the results obtained. His report on his "preliminary results of an attempt to detect the general magnetic field of the sun" was published in the July 1913 number of the *Astrophysical Journal.*[2]

All observations have been made thus far with the slit of the spectroscope set on the sun's central meridian. The measured displacements, suffered by the lines of the solar spectrum when the glowing vapors, from which they originate, pass thru the magnetic field, are those due almost exclusively to the component of the field at right angles to the sun's axis of rotation. The reason for this is a two-fold one: First, the terrestrial observer of solar phenomena is nearly always in the plane of the solar equator so that his line of sight is practically always perpendicular to the sun's axis of rotation. Twice a year, about December 5 and June 3, it is exactly so, and midway between these dates the maximum deviation from perpendicularity is but 7°15′. Secondly, the certain detection of the small displacements must at present be confined, because of the comparative weakness of the field, to the Zeeman effect obtained when looking *along* the lines of magnetic force. The detection of the effects at right angles to the lines of magnetic force, and the possibility of thus measuring also the component of the sun's magnetic field parallel to the axis of rotation, appears almost hopeless. Altho the solar magnetician is therefore not able at present to map the magnetic forces prevailing over the sun with the same completeness and definiteness as can be attained with respect to the earth's magnetic field, nevertheless, much has already been accomplished.

[2] See also his preliminary note in J. Terr. Mag. and Atmos. Elec., **17**: 173. 1912.

In Hale's published report, the Zeeman displacement which had been detected with sufficient certainty, was tabulated for various heliographic latitudes for the three lines: λ5812.139, λ5828.097 and λ5929.898, all of which probably originate at comparatively low levels on the sun. The present analysis is based entirely on these published data and, since these are designated by Hale as preliminary ones, the results derived accordingly from this analysis must be regarded as wholly preliminary and as likely to be superceded by later ones which may be based upon more extensive observations. The prime purpose here has been to ascertain if precisely the same method of analysis be employed for the solar magnetic data, as for the terrestrial magnetic data, some indications, at least, are obtained to show whether or not the magnetic fields of the two bodies follow somewhat analogous laws. In order to obtain strictly comparable data, it was necessary to make at the same time a fresh analysis of the earth's magnetic field on the basis of the same magnetic component involved in the solar data, and applying to the region 60° north to 60° south.

The chief results deduced from this first analysis of the sun's general magnetic field are:

1. The magnetic axis, as determined from the published data between the parallels 60° north to 60° south and for the four series of observations between January 1912 to February 1913, is found to be inclined, for the sun, 9° to 12° to the axis of rotation. The same angle of inclination for the earth was 11°.6, in 1885.

2. The sun's magnetic field is asymmetrical about the equator in much the same manner and in the same direction as is that of the earth. It is quite possible that the sun's actual magnetic poles, or equivalent points, as in the case of the earth, will be found not to be diametrically opposite each other.

3. The analysis determined four instants, distributed over a year, when the north end of the sun's magnetic axis was on the central meridian. Since a whole number of rotations of the sun must have occurred during the intervals between the four instants, it was possible to determine a period of rotation which applies, perhaps, to the sun as a whole, instead of to the surface, as is the case with the methods hitherto used. The synodic period of nearly 33 days which represented the present magnetic data best, differs considerably from the period usually regarded as the solar rotation period. It will therefore be highly

important, from a cosmical standpoint, to test the new period as soon as additional series of observations are available. It may also play an important part in the discovery of the cause of the sun-spot cycle, however, the period obtained must be regarded at present as but a preliminary one.

4. It is found that the solar magnetic field is as complex as that of the earth and that the distorting or disturbing systems which are superposed upon a primary, simple magnetic field follow laws very similar to those disclosed in the study of the terrestrial magnetic field. Thus, for example, the plane containing the magnetic axis of the sun is displaced in passing from the northern to the southern hemisphere in precisely the same direction, eastward (in the direction of rotation), as was found to be the case with the earth's magnetic axis. Accordingly, to give the requisite precision to the term "magnetic axis," the region from which it is determined must be carefully stated, as well as the method employed for fixing its position.

The close analogies that thus appear to exist between the magnetic field of the sun and of the earth, coupled with the fact disclosed by Hale that the magnetic polarity of the sun corresponds to that of the earth, may possibly indicate, since the direction of rotation of the two bodies is the same, that the origin of both magnetic fields will have to be referred finally to similar causes. In any case, the fact that the sun's field turns out to be as complex and as irregular as that of the earth and that these apparent irregularities follow similar laws for both bodies, would seem to strengthen the conclusion already reached in the investigation[3] of the terrestrial magnetic field, that it may not be necessary to refer the cause of the non-coincidence of the magnetic axis with the axis of rotation chiefly to heterogeneity of structure of the bodies under discussion.

[3] A consistent theory of the origin of the earth's magnetic field. This Journal, **3**: 1. 1913, and On the origin of the earth's magnetic field (Phys. Rev. N.S., **1**: 256. 1913.

RADIOTELEGRAPHY.—*Further comparison of arc and spark radio transmission.* L. W. Austin, U. S. Naval Radio Telegraphic Laboratory.

In order to make a comparison of the relative desirability of arc and spark transmission under summer conditions, a test was carried on between the Arlington station and Colon during the months of July and August of the present year. This time was chosen for the test on account of the fact that the signals are weakest at this period of the year, while at the same time the atmospheric disturbances are the strongest, so that the test may be considered as carried on under the most trying conditions. Hitherto all the long distance tests carried on by the Navy Department in connection with Arlington have been made during the winter months, when atmospheric disturbances are at a minimum and all conditions are favorable to long distance transmission. It was especially wished to make a comparison of the relative desirability of arc and spark transmission under summer conditions in order to determine whether the conclusions favorable to the arc, which had been drawn from the Arlington-Salem tests, would be supported.

For this work a 100 k.w. Poulsen arc belonging to the Universal Radio Syndicate was available for comparison with the regular rotary gap set of the Arlington station. The regular experiments began on July 25. The distance from Arlington to Colon is 1780 nautical miles. From the formula deduced from the Brant Rock experiments, the Arlington signals, at a wave length of 4000 meters, should be faintly audible at this distance, using a sensitive crystal detector and an antenna 200 feet high. As a matter of fact, the signals are just below audibility with ordinary detectors, as is shown from their strength on the more sensitive ticker. This fact may be due to the passage of the waves over Cuba, or to other conditions of transmission in this portion of the world.

The receiving work at Colon was done by Chief Electrician Meneratti, assistant at the Naval Radio Laboratory. The receiving apparatus used consisted of a Federal receiving set, which

is especially efficient at the longer wave lengths, a slipping contact ticker, and a Fessenden heterodyne. The regular antenna of the Colon station, 180 feet high and of about 0.004 m.f. capacity, was used for the work. The arc signals were sent out from Arlington at wave lengths of 4000, 5000, 6000 and 7000 meters. Two wave lengths were used with the spark, 3500 meters and 2500 meters. The latter, however, proved so unsatisfactory at this distance that its use was abandoned after the first few days.

On account of the continuous atmospheric disturbances quantitative comparisons were of little value. The following table gives the number of schedules sent at the various wave lengths, and the corresponding number received:

| | Wave length | Sending current amp. | Total schedules | | Schedules heard | |
|---|---|---|---|---|---|---|
| | | | Day | Night | Day | Night |
| | m | | | | | |
| Spark | 3500 | 104 | 9 | 0 | 7 | 0 |
| Arc | 4000 | 52 | 9 | 4 | 7 | 4 |
| Arc | 5000 | 60 | 0 | 4 | 0 | 4 |
| Arc | 6000 | 70 | 6 | 0 | 2 | 0 |
| Arc | 7000 | 78 | 3 | 7 | 3 | 7 |

The table shows that the best results were obtained with the arc at 7000 meters, every schedule being successfully received. The same is true of the 5000 meter arc waves, but in this case all the work was done at night which prevents its being properly compared with the other schedules. The 4000 meter arc and the 3500 meter spark waves, which may be fairly compared, were received with the same degree of regularity and were of approximately the same strength as compared on the slipping contact ticker. In this connection it must be remembered, as will be explained later, that while 90 per cent of the spark schedules were weakly audible on the heterodyne or ticker, practically none of the messages were readable. It appears from the report that 50 per cent of all the arc messages sent at the various wave length, that is, 65 per cent of the arc schedules heard at all,

would have been completely readable by double repetition. The very poor showing of the 6000 meter wave, compared with the 4000 and 7000 meter waves, is probably due to a defect in the receiver at this wave length.

One of the most interesting portions of the work was the study of the behavior of the ticker and heterodyne under the conditions of continuous atmospheric disturbance at Colon. The reports indicate that the heterodyne is somewhat more sensitive than the ticker, but that the difference is not very great. With spark signals the note produced by both is unmusical and difficult to distinguish from the atmospherics, and both are inferior to a good crystal detector in receiving weak 500 cycle signals thru continuous atmospherics. With arc signals, however, the case is entirely different. Here the slipping contact ticker produces the same rustling sound as in the case of the spark, but the heterodyne produces a musical note of any pitch found most suitable for reading thru the disturbances.

# ABSTRACTS

**Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.**

GEOPHYSICS.—*The hydrothermal formation of silicates, a review.* GEORGE W. MOREY and PAUL NIGGLI. J. Am. Chem. Soc., **35**: 1086–1130. 1913.

This is a discussion of the theoretical principles underlying the behavior of water-silicate systems at temperatures ranging up to 500°, followed by an annotated bibliography in which are assembled all of the data relating to hydrothermal syntheses. These data unfortunately afford practically no reliable quantitative information; qualitatively, even, they leave much to be desired, for many minerals have been obtained but once by a given investigator, in a manner which was not reproducible and under conditions which were not specified. The minerals which have been most commonly obtained are chiefly those which are stable—or at any rate phanerostable—over a wide range of conditions; for example, quartz and the feldspars. In all cases the crystals obtained are very small, so that accurate chemical analysis is usually out of the question; their identification by optical methods may even be doubtful.

Hydrothermal syntheses, like the paragenetic relationships investigated by Van't Hoff, are determined by the solubility relations of all the possible solid phases which may be formed from the components present in the solution, even altho the concentration of these components in the solution is vanishingly small. Many of the reactions are, without doubt, practically restricted to the solid phase, altho they take place thru the medium of the solution. These solubility relationships are thus not simple; but study of the question is further complicated by the frequent appearance of metastable phases, which again is coördinated with the rates of the various possible reactions. Now, as is well known, rates of reaction are often affected very greatly by factors which in other respects are of altogether minor importance; hence slight differences, e.g., in the composition, or even in the texture or fineness of grain, of the initial solid phase—may exert considerable influence on the

result. These considerations serve to show that there may in certain cases be difficulties in the way of always being able to reproduce a given result; in order to do this in any case, it is necessary to control carefully the amount of water relative to the volume of the containing vessel (the degree of filling), the temperature, and, if possible, the pressure also. The critical point of water is only a secondary factor in determining the nature of the product, its influence being effected principally thru the change in concentration of the solvent (liquid or fluid) in the neighborhood of the critical point.

The thoro investigation of hydrothermal syntheses is beset with many difficulties, apart from the technical problems inherent in operating on heterogeneous systems within closed bombs at high temperatures. Nevertheless our knowledge of the real relationship of these minerals can be advanced materially if care is taken to control the factors involved, the most important of which are the initial composition of the system (including therein the relation between the amount of water and the volume of the bomb) and the temperature. G. W. M. and P. N.

PHYSICS.—*Densities at high temperatures.* ARTHUR L. DAY, R. B. SOSMAN and J. C. HOSTETTER. Am. Jour. Sci. (4). 1913.

The existing and rather conflicting data on the volume change of rocks on fusion are reviewed briefly. A method and apparatus is described for the determination of the specific volume of metals or of solid or fused silicates from 200° to 1600°. The basis of measurement is the expansion of artificial graphite, which was determined from 20° to 1500°. Volume curves are given for tin, lead, and the eutectic of lead and tin. Measurements were made on quartz up to 1600°. The volume of quartz increases more and more rapidly as 575° is approached. At this point the inversion takes place to the high-temperature form, whose volume decreases slightly with rising temperature. Between 950° and 1250° gasses are given off. Above 1300° the volume is increased greatly by the formation of cristobalite. Granite shows the same form of curve as quartz. Above 500°, however, it is not possible to obtain its true volume expansion because of the shattering and permanent dilation due to unequal expansion of the minerals and to escape of gasses. The same is true of crystalline diabase.

The curve of glassy diabase can be obtained, however. The glass crystallizes with contraction of volume at about 900°, then begins to fuse again at about 1150°. On cooling, the liquid again crystallizes with contraction. This behavior explains completely the results of Barus,

which have been widely quoted. A recalculation of his data on the basis of redetermination of his fundamental volume show them to be in good agreement with the new measurements. The bearing of these data upon the occurrence of "floated" slabs of rock in the Palisade diabase is discussed.
A. L. D.

CHEMISTRY.—*A method for the determination of magnesium in calcium salts.* J. C. HOSTETTER. J. Am. Chem. Soc. 1913.

The usual methods for the determination of magnesium in the presence of calcium are not applicable when the latter element amounts to as much as 1000 times that of the magnesium. The essential feature of the method here presented is the concentration of the magnesium into a precipitate containing but a small amount of calcium. This concentration is effected by precipitating Mg $(OH)_2$ with a slight excess of solid Ca $(OH)_2$. The magnesium in this precipitate is determined as pyrophosphate after removal of the calcium by two oxalate precipitations. Determinations in some 30 highest-grade calcium salts show, generally, far more magnesium than reported by the makers.
J. C. H.

PHYSICAL CHEMISTRY.—*The phenomena of equilibrium between silica and the alkali carbonates.* PAUL NIGGLI. J. Am. Chem. Soc., **35**: 1692–1727. 1913.

This is a record of an experimental investigation of the equilibrium between silica and melted alkali carbonate, at temperatures of 900–1000° and under a pressure of 1 atm. carbon dioxide. A series of experiments were made with the carbonates of potassium and sodium, and a few with lithium carbonate. The systems $R_2O$-$SiO_2$-$CO_2$ (R = K, Na, Li), under the above-mentioned conditions behave similarly on the whole, and differ only in details. Silica added to alkali carbonate is transformed into silicate as long as any carbonate remains. In the melts there is equilibrium between carbonate and pairs of silicates, as follows:

$$\text{I}\quad K_2CO_3 + K_2Si_2O_5 \rightleftarrows 2K_2SiO_3 + CO_2$$

$$\text{II}\quad Na_2CO_3 + Na_2SiO_3 \rightleftarrows Na_4SiO_4 + CO_2$$

$$\text{III}\quad \text{(presumably) } 2Li_2CO_3 + Li_4SiO_4 \rightleftarrows Li_8SiO_6 + 2CO_2$$

The solid phases, which separate from the melts, consist of silicate or carbonate, but contain no free silica until the proportion of silica exceeds that corresponding to the higher silicate. The amount of carbonate depends only on the ratio $R_2O/SiO_2$, when external conditions are constant; when this ratio becomes identical with that of the silicate

richer in silica, the melt is free from carbon dioxide. In each case the compound containing more silica is the poorest in silica which can be prepared pure at the particular temperature merely by putting together carbonate and silica. Moreover, rise of temperature, the pressure remaining constant, favors the lower silicate.

The study of systems of this type is important because their behavior serves as a simple prototype of that of the magma, which is a highly complex system containing both volatile and non-volatile components. The so-called "mineralizers" are merely volatile components; the effects of their presence differ only in degree from that of the other components. The main difference is due to the vastly greater effect of changes of pressure and of temperature on the concentration (in the melt) of the volatile component, by reason of the close relation of the concentration to that of the gas phase itself. In consequence of this, there is a "mobility" of equilibrium which is characteristic of the magma and without doubt very closely associated with many aspects of its behavior, e.g., with the likelihood of eruption, differentiation, etc. P. N.

MINERALOGY.—*The melting phenomena of the plagioclase feldspars.* N. L. Bowen. Am. Jour. Sci. (4), **35**: 577–599. 1913.

The method of quenching was applied to the determination of the melting intervals of pure, artificial plagioclase feldspars. It was found possible to determine accurately the temperatures of beginning of melting (solidus) for compositions ranging from pure An to $Ab_3An_1$ and of completion of melting (liquidus) for the range An-$Ab_8An_1$. Very pure natural material, Bakersville oligoclase was used to determine the point on the solidus corresponding to its composition. Similar material, Amelia County albite, served to fix the melting point of albite. The results of this work are summarized below:

| Composition | Temperature of beginning of melting. Solidus | Temperature of completion of melting. Liquidus |
|---|---|---|
| An | 1550° ± 2° | 1550° ± 2° |
| $Ab_1An_3$ | 1465° ± 4° | 1521° ± 2° |
| $Ab_1An_2$ | 1372° ± 4° | 1490° ± 2° |
| $Ab_1An_1$ | 1287° ± 4° | 1450° ± 2° |
| $Ab_2An_1$ | 1205° ± 5° | 1394° ± 2° |
| $Ab_3An_1$ | 1175° ± 8° | 1362° ± 2° |
| $Ab_{77.5}An_{22.5}$ | 1158° ± 5° | |
| $Ab_4An_1$ | | 1334° ± 2° |
| $Ab_8An_1$ | | 1265° ± 3° |
| $Ab_{98}An_2$ | 1100° ± 10° | |

It was also found possible in several instances to determine the composition of the liquid phase, present at temperatures within the melting interval, by measuring the refractive index of the quenched glass. Thus points on the liquidus were determined by an independent method and were found to be in excellent agreement with the results of the temperature method.

In the theoretical discussion, equations are developed which express the concentrations on the liquidus and solidus at any temperature in terms of the melting temperatures and latent heats of melting of the two components. The experimental results therefore make possible the calculation of the latent heat of melting of anorthite and of albite. The calculated values are 104.2 calories per gram for anorthite and 48.5 calories per gram for albite and these values remain practically constant for all ranges of composition. The calculated latent heat of anorthite is in excellent agreement with the figure found by direct measurement, 105 calories per gram. No direct determinations of the latent heat of albite have been made. It is shown that if these values of the latent heats are taken and liquidus and solidus curves calculated, the resulting curves pass very close to the experimentally determined temperatures (within the limits of error of the temperature measurements). It is also shown that values of the latent heats differing from these by as little as 10 per cent will not give a like result. This extreme agreement with the requirements of theory and its bearing on certain theoretical questions is discussed.

The geological significance of the complete solid solution of the feldspars is considered, as well as the extent to which zoning may occur under favorable conditions and the consequent great range of temperature thru which plagioclase may crystallize. N. L. B.

PETROLOGY.—*Graphical methods in microscopical petrography.* Fred Eugene Wright. Am. Jour. Sci. (4), **36**: 509–539. 1913.

Experience in microscopical petrography has shown that the results furnished by graphical means are, as a rule, sufficiently accurate and in accord with the quality of the data of observation. Graphical methods in petrography serve three purposes: (1) to solve certain equations, (2) to represent data of observation, and (3) to picture certain important crystallographical and optical relations. In all these cases it is essential: (a) that the graphical means employed represent the relations adequately and as free from distortion as possible; (b) that they are easy of application, and (c) that wherever possible the func-

tions be plotted in such a form that their changes can be represented by straight lines. Eight plates, drawn on these principles, are included, and furnish solutions for the following equations:

$$\sin i = n \sin R,\ \sin^2 i = n^2 \sin^2 \gamma,\ \frac{\gamma^1 - \alpha^1}{\gamma - \alpha} = \sin \vartheta_1 \sin \vartheta_2,$$

$$\tan^2 V_\alpha = \frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{\alpha^2} - \frac{1}{\beta^2}},\ \tan V_\alpha = \sqrt{\frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{\alpha^2} - \frac{1}{\beta^2}}},\ \cot A = \sin B \cdot \cot C, \text{ and}$$

$\sin A = \sin B \cdot \sin C.$ F. E. W.

PETROLOGY.—*A graphical plot for use in the microscopical determination of the plagioclase feldspars.* FRED. EUGENE WRIGHT. Am. Jour. Sci. (4), **36**: 540–542. 1913.

On this plot the changes in the optical properties of the plagioclase feldspars with chemical composition are indicated by a set of curves, the purpose being to furnish the petrologist, in convenient form and on a single sheet, all the constants essential for the accurate determination of the plagioclase feldspars in thin rock sections. A new set of curves for the extinction angles on sections showing symmetrical carlsbad-albite twinning is included, the values having been derived graphically from the best available measurements on plagioclase feldspars.

PETROLOGY.—*Oblique illumination in petrographic microscope work.* FRED EUGENE WRIGHT. Am. Jour. Sci. (4), **35**: 63–82. 1913.

The study of interference phenomena resulting from oblique illumination between crossed nicols enables the observer to determine many optical features in a given mineral plate. These phenomena are identical, so far as interference colors go, with the phenomena obtained in interference figures from the same plate in convergent polarized light. The study of mineral plates by the method of oblique illumination is of value because it impresses the mind of the observer with the interdependence of optical and crystallographic properties. It is, however, highly important that the observer realize the essential agreement between the phenomena observed in oblique illumination and those seen on interference figures in convergent polarized light. In the interference figures the interference color phenomena are seen at a glance, and if they be studied with reference to the position of the mineral

from which they are obtained, all of the conclusions to be ascertained by means of the method of oblique illumination can also be derived with even greater facility from the interference figure. For the study of interference phenomena the method of oblique illumination does not offer any special advantages over the convergent polarized light method, but it does present certain disadvantages in manipulation and in the distinctness of the phenomena observed which cannot be disregarded entirely. This is especially true if oblique illumination be obtained by use of a stop in the eye circle of the ocular as recently suggested by Schneiderhöhn.

In this paper, the phenomena produced by oblique illumination are discussed in some detail. Attention is directed to an obvious but important fact, too often disregarded in petrographic microscope work, that for the accurate measurement of extinction angles central illumination by parallel plane-polarized light is highly essential. Satisfactory measurements of extinction angles cannot be made when the section is illuminated by a strongly convergent cone of light, incident under all angles and in all azimuths, F. E. W.

GEOLOGY.—*The volcanic cycles in Sardinia.* H. S. WASHINGTON. Comptes Rendus Congrès Géologique International XII, Toronto, 1913.

The volcanoes of northwestern Sardinia were studied in the autumn of 1905. They belong to three distinct periods, with interesting lavas, which show very marked cycles, or recurrent successions of characters, in their eruptions. These lavas are now being studied, and are to be described soon, along with some forty analyses, in a series of papers.

Taking these volcanoes as a text, some broad subjects of modern petrology are discussed briefly. It is pointed out that, while no one sequence of types is generally applicable, the sequence seems to vary with the magmatic character and usually closes with basalts, tho any generalizations must be rather hazardous owing to the inherently accidental character of the rock sequences observed by us. A change in the character of the magma and in the volcanic cycles seems to be connected with a change in the mode of volcanicity, the relation being possibly a causal one, but the inadequateness of present data for such studies is pointed out. The so-called Atlantic and Pacific tribes of rocks are briefly discussed and objections raised against them, it being urged among other things that it is illogical and unjustified to select only two types for contrast to the exclusion of others equally important. In con-

clusion, the importance of further and more detailed systematic study of volcanoes, the need of numerous chemical analyses, the importance of the application of physico-chemical research to petrological problems, and the magnitude and complexity of such future investigations, are insisted on. H. S. W.

GEOLOGY.—*The general principles underlying metamorphic processes.* JOHN JOHNSTON and PAUL NIGGLI. J. Geol. **21**: 481–516. 1913.

This paper is an endeavor to set forth the most important general principles concerned in rock metamorphism—a general term which includes a number of special cases all of which, however, differ only in the degree of predominance of one (or more) of a definitely limited group of effective factors. These factors are: temperature, uniform pressure, stress (non-uniform pressure), and gross composition of the system at the time of metamorphism; the same, namely, which determine the equilibrium of the relatively simple chemical systems hitherto investigated experimentally. The knowledge gained from a study of these simple systems may be used as a basis for a prediction of the general character and significance of metamorphic processes; tho in applying the principles one must always bear in mind th se circumstances which oppose the attainment of a state of true equilibrium, such, for example, as slowness of reaction or the formation of metastable intermediate products.

Now, altho the general character of the process may be predicted, no particular statement as to the effects produced in a given system by change of any of the above factors can yet be made, owing to lack of the requisite quantitative data. In this connection, it is to be noted that the general application of experimental results which obtain for a given system under given external conditions, to another system under similar conditions, or even to the same system under widely differing conditions, is subject to considerable limitation. Conclusions drawn from such extrapolation of experimental evidence will commonly be of little value, and may be altogether misleading; moreover, one may as well guess the final result as arbitrarily choose the data required in calculating it. From this we see that the application of the above simple principles, which determine rock metamorphism, to the complicated rock systems will be no simple matter, but will require extended experimental investigation and a long time. In such investigation the first thing necessary is a definite conception of the general processes of rock metamorphism; this it was the purpose of the authors to present. The choice of par-

ticular problems in this large field will doubtless be aided greatly by a study of natural mineral associations from the physical chemical standpoint, a study which at the same time will certaily provide us with information bearing directly on the problems at issue. J. J. and P. N.

GEOLOGY.—*Geology of the Koyukuk-Chandalar region, Alaska.* A. G. Maddren. U. S. Geological Survey Bulletin 532. Pp. 116, with maps and views. 1913.

The Koyukuk-Chandalar Region, as here described, embraces the greater part of two coextensive basins, situated north of the Arctic Circle, from which flow the Koyukuk and Chandalar Rivers, large northern tributaries of the Yukon River. Placer gold bearing gravels occur along the upper branches of several of the principal tributaries of these large rivers, and the exploitation of these deposits since 1899, with a total production of about $3,000,000, has given the region its economic importance and the distinction of being one of the northernmost gold mining districts in the world. Gold lode deposits also occur about the sources of Big Creek in the Chandalar Valley.

The general geology of these two basins is similar. The bedrock consists largely of a complex of highly metamorphosed schistose, probably pre-Cambrian or early Cambrian, sediments of mica-quartz, quartzitic, and phyllitic types. In these schists granitic intrustives of late Cretaceous or early Tertiary age occur, which are in part metamorphosed but in part also comparatively unaltered. The mineralization, that has been locally induced by some of these intrusives, appears to be largely accountable for the gold. Across the central part of the region extends a belt of more or less metamorphosed sediments, largely made up of cherts and fine-grained quartzites, considered to be of Devonian age. The northern mountainous belt of the region is largely occupied by a thick series of massive, probably Carboniferous, crystalline limestones in which are some thinner beds of semi-schistose sediments. In the southwestern part of the region the central Koyukuk Valley is occupied by Cretaceous sediments, largely marine and unmetamorphosed, but considerably folded and somewhat faulted. Only one small isolated area of Tertiary sediments is known. It is on upper Dall River and contains at least one bed of lignite. There are also some horizontal basaltic and andesitic flows in the southern part of the district which are probably of late Tertiary or early Quarternary age.

The mountainous northern half of the region has been heavily glaciated. The headwater valleys, both of the Chandalar and Koyukuk

basins, owe their present bed rock configuration to the erosion effected by long valley glacier ice streams that had their sources on the Arctic divide and flowed southward. Upon the retreat of these valley glaciers, which have now entirely disappeared from this part of the Arctic Mountains, widespread deposits of glacial outwash gravels, sands, and silts were left along the large valley. The present large streams have dissected and aggraded their flood plains but large quantities of the older gravels still remain as wide sloping terraces. In many cases the gold-bearing gravels represent old pre-glacial stream gravels. These deposits are now buried under silts and recent stream gravels and are mined by shafts and drifts. But most of the gold production has been from shallow deposits of gravel along the present streams. A. G. M.

GEOLOGY.—*Ore deposits of the Helena mining region, Montana.* Adolph Knopf. Bulletin U. S. Geological Survey No. 527. Pp. 143, with maps, sections, and illustrations. 1913.

The Helena mining region is an area of 1300 square miles in southwestern Montana. The oldest rocks consist principally of sediments ranging in age from Algonkian to Cretaceous. They include mainly limestone, shale, and quartzite and lie in angular accordance from the lowermost member to the top of the series. They are conformably overlain by andesite and latite lavas and breccias of probable late Cretaceous age. These older rocks were invaded by a large granite mass which forms the northern extension of a great intrusion in southwestern Montana, known as the Boulder batholith. Large intrusions of aplite in irregular masses and dikes followed the main irruption. They are commonly tourmaliniferous, and in places, notably so. In late Miocene time, a series of dacites, consisting of lavas, tuffs and breccias, locally at least 2400 feet thick, were extravasated upon the deeply eroded surface of the granite and older rocks.

The ore deposits of the region fall into two distinct groups, widely separated in time of origin. The older are late Cretaceous or early Tertiary in age, the younger are post-Miocene. The ore bodies of the first period of mineralization are mainly argentiferous lead and gold-silver deposits. They have furnished the greater part of the production of the region; in fact, the value of their output has been roughly three times that of the post-Miocene deposits. The argentiferous lead deposits constitute the prevailing type of ore body of the older group. They are situated as a rule near the contact of the granite and the rocks invaded by it, and are replacement-fissure lodes containing galena, sphal-

erite, pyrite, and arsenopyrite. They are commonly tourmaliniferous. In certain deposits, as at Rimini, tourmaline is extremely abundant; in fact, it occurs there in the same abundance that characterizes the tin lodes of Cornwall. Three types of tourmalinic lodes with transitions between them are recognized—lead-silver, copper-silver, and gold. The predominant is the tourmalinic lead-silver, a type peculiar to the region, so far as shown by the literature of ore deposits. The ores were formed at high temperatures, and it is regarded as probable that the ore-forming solutions were a final differentiation product of the granitic magma.

The ore bodies of post-Miocene age are essentially precious-metal deposits. They are characterized by the tendency of the quartz gangue to display a cryptocrystalline development, either flinty, chalcedonic, or densely saccharoidal, resembling porcelain. Equally characteristic is the thinly lamellar calcite of the gangue and its pseudomorphic replacement by quartz, forming a type of ore common in so many of the late Tertiary gold fields of the Western States. In common with these the tenor of the ores decreases abruptly below the 500-foot level. These deposits are typically developed in the upper Miocene dacites of Lowland Creek, but their analogues at Marysville have furnished the bulk of the output. A. K.

PALAEONTOLOGY.—*Cambrian Holothurians.* AUSTIN H. CLARK. American Naturalist **47**: 488–507. August, 1913.

Among the remarkable organisms described from the Cambrian of British Columbia during the past year by Dr. Walcott were a number which he referred to the Holothuroidea, the most extraordinary of these being a pelagic animal called by him *Eldonia ludwigi.* As the correctness of the determination of these creatures as holothurians was questioned in a review by Dr. Hubert Lyman Clark, the present author was led to reply to his criticism for the reason that, as stated in Dr. Walcott's original paper, it had been he who first suggested the possibility that *Eldonia* might be a holothurian, tho he had not at the time examined the other specimens.

Dr. Walcott, Dr. Hubert Lyman Clark and the present author all made independent investigations upon the material in question, and the last mentioned was led to the following conclusions: *Eldonia* is a free-swimming holothurian, and is most closely related to the species of the family Elpidiidae. In body form alone does *Eldonia* resemble a medusa; this general resemblance may therefore be safely disregarded

as a parallelism resulting from a similar pelagic habit. In the general shape of the body as well as in the course of the digestive tube *Eldonia* approaches *Trochosphaera* (and trochophore larvae); but the enormous discrepancy in size, the broad fringe about the body, the large tentacles on either side of the mouth, the absence of muscles of the group type characteristic of the rotifiers, and the submarginal anus, seem to negative the idea that the two can be in any way related. The medusoid body form, the absence of a protrusible proboscis and the presence of a large branched tentacle on either side of the mouth appear to offer conclusive evidence that *Eldonia* cannot be a worm. The digestive tube of *Eldonia* resembles that of the heteroradiate echinoderms, and especially that of certain holothurians; the tentacles on either side of the mouth suggest an affinity with the holothurians; the radial canals leading to a central ring are comparable to the radial canals and the central ring of the holothurians; the broad circular muscle about the body suggests a modified longitudinal holothurian muscle, and is of the group type characteristic of the echinoderms; the broad brim about the body is strikingly similar to the brim developed in certain elpidiid holothurians, such as *Euphronides tanneri* and *Scytoplanes typicus*. A pelagic holothurian is known as an inhabitant of the recent seas; tho very different in origin and in affinities from *Eldonia* it demonstrates that a pelagic habit is not impossible in the group. The species of the family Elpidiidae are preëminently inhabitants of the deep sea; this suggests that the fossil representatives of the family should be found in very early geological formations. Therefore *Eldonia* is a pelagic holothurian, related to the species of the family Elpidiidae.

No marine animals are known outside of the holothurian family Elpidiidae which have a body form like that of *Louisella pedunculata* in all its details; but this species agrees in every particular with one or other of the species in that family. We cannot, therefore, escape the conclusion that *Louisella pedunculata* should find a place in the family Elpidiidae along with all the recent animals which in any way resemble it.

By exactly the same reasoning *Laggania cambria* is assigned to a position in the same group.

The type specimen of *Mackenzia costalis* shows a pleated structure which can only be interpreted as due to longitudinal mesenteries, probably eight in number; there appear to have been sixteen processes around the mouth which probably indicate tentacles retracted before preservation; the distal portion of the body resembles closely the distal

portion of the body in the genus *Edwardsia*. Thus, as *Mackenzia costalis* presents characters not found outside of the Zoantharia, and in that group peculiar to the family Edwardsiidae, it seems necessary to assign it to a position in the family Edwardsiidae, near the genus *Edwardsia*.

In brief the disposition of these fossils is as follows:

Holothuroidea
- Family Elpidiidae
  - Genus *Laggania*
  - Genus *Louisella*
- Family Eldoniidae (near the Elpidiidae)
  - Genus *Eldonia*

Zoantharia
- Family Edwardsiidae
  - Genus *Mackenzia*.

A. H. C.

BOTANY.—*Feroniella, genre nouveau de la tribu des* Citreae, *fondé sur le* F. oblata, *espèce nouvelle de l'Indo-Chine.* WALTER T. SWINGLE. Bull. de la Soc. bot. de France, **59**: 774–783. Fig A, Pl. 18. No. 8, séances novembre-décembre, 1912. Pub. Feb. 18, 1913.

To the eight known species of hard-shelled citrous fruits, comprising four genera, is added a ninth species, *Feroniella oblata*, from Cochin-china, the type of a new genus Feroniella. This genus resembles Feronia in having pinnate leaves, large flowers and one-celled fruits due to the fusing of the 5 to 6 ovary cells, and differs from it in having twice the number of stamens (four times as many as the number of petals), filaments with hairy basal appendages, smooth seeds, and the epicarp composed of radially disposed prismatic elements. Appendices to the filaments are not known in any other plant hitherto studied of the tribe *Citreae*. The hairs of the appendices become entangled and form a sort of cup, protecting the base of the ovary from insects too small to effect pollination. The structure of the epicarp of the fruit also differs in its radially disposed woody structure from that of the other genera of this tribe.

The type of the genus, *Feroniella oblata*, takes its specific name from the shape of the fruit which is a flattened spheroid like a mandarin orange. A cross section of the fruit is figured and an excellent plate shows a twig with leaves and flowers, giving the flower structure in detail. This tree, which attains a height of 8 to 20 meters, is found

thruout Cambodia and also occurs in Cochinchina, central Laos and eastern Siam.

*Feronia lucida* Scheff. is transferred to this genus, becoming *Feroniella lucida* (Scheff.) Swingle. MAUDE KELLERMAN.

ZOOLOGY.—*Revision of the crinoid genus Himerometra.* AUSTIN HOBART CLARK. Proceedings of the U. S. National Museum, **46**: 279–289. 1913.

This paper includes a history of the genus, a list of all the references to the included species, correctly identified, a key to the species, a list of the six species with the synonymy, range and depth of each, and a discussion of the phylogenetical interrelationships within the group.

This genus differs from the more closely related genera in having the proximal or lower pinnules very much enlarged, with the first the longest and the following decreasing in size. There are three specific groups within the genus of two species each, distinguished by different stages in the specialization of the lower pinnules. In the first, least specialized, group these pinnules are scarcely stouter than in the allied genera, but they are long and flagellate, the first being the longest. This group ranges from the East Indies to the Persian Gulf. In the second group the lower pinnules are very stout, but they possess a flagellate tip. This group ranges from the East Indies to the Maldive Islands. In the third, most specialized, group the lower pinnules are extremely stout, and end abruptly without a flagellate tip. This group occurs from the Moluccas and the Philippine Islands to the Mergui Archipelago. In all of the three groups the more specialized of the two species occurs in the Malay Archipelago. A. H. C.

TECHNOLOGY.—*The metric carat.* Bureau of Standards Circular No. 43.

After July 1, 1913, the metric carat of 200 mgms. is recognized as the standard of weight for diamonds and other precious stones and this standard will be used in the certification of all carat weights submitted to the Bureau after that date. The Treasury Department also adopted this standard on the same date for use in the customs service in levying the duties on gems. The change from the former uncertain and indefinite carat weight, usually equal to about 205.3 mgms., to the definite and impler metric carat was facilitated in the United States by the joint action of all the large dealers in diamonds, pearls and other precious stones, who, realizing the chaotic condition due to the various

weights used as a carat, after recommendation by the International Bureau of Weights and Measures and the Bureau of Standards decided upon the metric carat as the solution of the difficulty and decided to put its use into effect on the same date. Until recently nearly every civilized country of the world has used a different standard of weight for diamonds. Many of the nations, however, have lately adopted the one unit of a carat of 200 mgms., and Spain, Italy, Bulgaria, Denmark, Norway, Japan, Portugal, Roumaia, Switzerland, Sweden, France, Germany, Holland and Belgium are in the list with the United States of those countries which now have the new international standard. In England the change has not yet been adopted.

The circular gives complete tables by which weights in the old carats can be determined in terms of the new unit and vice versa, and also calls attention to the need of more accurate weighing of precious stones because of their great value and especially of greater care of the balances and weights used for the purpose. R. Y. FERNER.

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*The density and thermal expansion of linseed oil and turpentine.* H. W. BEARCE. Pp. 27. 1912.

*The melting points of fire bricks.* C. W. KANOLT. Pp. 17. 1912.

*Comparison of five methods used to measure hardness.* RALPH P. DEVRIES. Pp. 27. 1912.

*Action of the salts in alkali water and sea water on cements.* P. H. BATES, A. J. PHILIPS, AND RUDOLPH J. WIG. Pp. 157. 1912.

*The evaporation test for mineral lubricating and transformer oils.* C. E. WATERS. Pp. 13. 1913.

*Legal specifications for illuminating gas.* E. B. ROSA and R. S. MCBRIDE. Pp. 31. 1913.

*Surface insulation of pipes.* BURTON MCCOLLUM and O. S. PETERS. 1913.

*The manufacture of lime.* W. E. EMLEY. Pp. 130. 1913.

*The function of time in the vitrification of clays.* G. H. BROWN and G. A. MURRAY. Pp. 26. 1913.

*Electrolysis in concrete.* E. B. ROSA, BURTON MCCULLOM, and O. S. PETERS. 1913.

*Physical testing of cotton yarns.* W. S. LEWIS. Pp. 31. 1913.

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# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 726th meeting was held on May 24, 1913, at the Cosmos Club, Vice-President Bowie in the chair; 33 persons present.

Mr. C. G. Abbot presented a paper on *Results of measurements of solar radiation*. The essential features of this paper are presented in the article on *The variations of the sun* by Abbot, Towle and Aldrich published in this Journal, **3**: 309-315. 1913. Messrs. Humphreys, Paul and Hersey discussed the paper.

Mr. A. W. Gray then spoke on *The control of temperature in an electric furnace*. After a brief review of previous experiments to secure uniformity of temperature in an electrically heated air column by using the central portion of a sufficiently long tube and by crowding the windings near places where heat was lost most rapidly, the speaker described a development of the electric furnace. The independently heated end plugs of the earlier pattern were retained; two concentric cylindrical heaters of nichrome ribbon, wound longitudinally and separated by air and asbestos, supplied heat uniformly for entire length of the interior. The new winding distributes any irregularities in resistance in such a way as not to affect the longitudinal distribution of temperature, is non-inductive, limits difference of potential between adjacent windings to drop occurring in a length of ribbon twice as long as furnace, limits to this length the amount of ribbon that can be accidentally short-circuited, and brings out both terminals of a heater at same end of furnace and diametrically opposite. Lantern slides were presented showing results under various conditions. A further improvement consisted in moving heating coils of plugs to extreme ends of furnace, making it easy to secure uniformity of temperature within a few tenths of a degree over at least twice the length of the furnace. The paper was discussed by Mr. White as to point of highest temperature and mechanical details. At 10.00 p.m. the meeting adjourned.

The 727th meeting was held on October 11, 1913, at the Cosmos Club, Vice-President Bowie in the chair; 41 persons present.

Mr. L. J. Briggs presented a paper giving the results of an investigation by himself and Mr. H. L. Shantz on *The water requirements of plants*. The governing conditions determining the absorption of water by the roots of plants, its translocation thru the stems, and its final evaporation from the leaves were first discussed. Attention was directed to peculiar structural modifications found in certain plants, which are apparently

for the purpose of reducing the loss of water. In view of these changes, wide variations as regards efficiency in use of water by different plants might be expected. The authors found this to be the case. The amount of water transferred is very great compared with the dry matter produced. In the experiments direct evaporation from the soil was prevented by the use of perforated covers, the openings about the stems of the plants being sealed with wax. Six pots were used for each variety, to provide a basis for calculating the probable errors of the water requirement ratios. The water requirement is profoundly modified by differences in climatic environment. The average for 25 varieties grown at Akron, Colorado, in 1912 was only $79 \pm 2$ per cent of that of the same varieties in 1911, while the evaporation in 1912 was $78 \pm 2$ per cent of that in 1911. Paper was illustrated by photographs and lantern slides. Upon request of the chair, Mr. SHANTZ made some additional remarks concerning the investigation. Botanists were interested in this question as early as 1699. The paper was discussed by Messrs. BOWIE, CURTIS, COBLENTZ, HUMPHREYS, and WENNER.

Mr. M. D. HERSEY then gave a brief review of the *Birmingham meeting of the British Association.* In the Engineering Section great interest was shown in the discussion of complex stress distribution and failures and in report on electrical units and nomenclature. In the Physical and Mathematical Section the papers dealt chiefly with modern theories of radiation. Reference was made to the Presidential and Vice-Presidential addresses and the relatively greater importance attached to the social and general features than with the American Association.

Upon the suggestion of Mr. Hersey, the chair invited Mr. W. F. G. SWANN to give informally brief abstracts of his papers before the Birmingham meeting on *The electrical resistance of thin metallic films* and on *The expression for the electrical conductivity of a metal.* The first give a theory to explain the abnormally high apparent specific resistance of a very thin film, while the second called attention to the fact that Drude's expression requires a correction in coefficient in denominator from 4 to 3. At 10 p.m. the meeting adjourned.

The 728th meeting was held on October 25, 1913, at the Cosmos Club, Vice-President Bowie in the chair; 30 persons present.

Mr. J. H. DELLINGER presented a paper on *The measurement of high frequency currents.* Three effects made use of in such measurements are electro-dynamic, electro-static, and thermal. The last is most successfully and generally used and four methods involving this effect were discussed. The different appliances, experimental apparatus, and standard instruments were briefly described. The theoretical considerations and formulae were discussed. The conclusions drawn were that circuit of ammeter must be simple, the straight wire type of instrument is superior, and that errors may be eliminated by use of high resistance. The paper was discussed by Messrs. OLSHAUSEN and ROSA.

Mr. F. W. WELLS then presented by invitation a paper entitled

*Interpreting irregular data.* The manifestations of nature are of utmost irregularity; of all sciences, that of agriculture is richest in data but poorest in correlation. The most generally used method for discussion is that of averages, but in biological and other fields this method is of little value. The author has been quite successful in the application of the integral of the probability curve to data of this character. Lantern slides were shown to illustrate such application to data for turbidity of Washington water before and after operation of filtration plant, and to data showing number of leucocytes in morning and evening milk. The paper was discussed by Messrs. HERSEY and SWANN.

Upon invitation of the chair, Mr. C. E. ST. JOHN, of the Mt. Wilson Solar Observatory, gave an informal report upon the social and scientific features of the recent conference of the Solar Union at Bonn. He abstracted briefly each day's proceedings. Reports were given by various committees on solar radiation; standard wave lengths; solar atmosphere; solar rotation, sun-spots and eclipses, and magnetic state of the Sun. The speaker referred particularly to the favorable reception accorded the work of Abbott and to the fact that the American contingent of workers is bearing its fair share in the development of solar research. The chair expressed the thanks of the Society to Mr. St. John for the report. At 10.00 p.m. the meeting adjourned.

J. A. FLEMING, *Secretary*

## THE GEOLOGICAL SOCIETY OF WASHINGTON

The 270th meeting of the Society was held in the Cosmos Club on April 23, 1913.

An informal communication was presented by B. S. BUTLER on *Basic ferric sulfates in Utah.*

### REGULAR PROGRAM

*A remarkable skeleton of Stegosaurus* (illustrated): C. W. GILMORE. The type specimen of *Stegosaurus stenops* recently prepared and placed on exhibition in the U. S. National Museum constitutes the most perfect skeleton of this remarkable dinosaur ever found. It is also unique in being the first specimen to give positive evidence as to the position and arrangement of the large dermal plates with which, in life, its back was adorned. The position of the various parts of the skeleton, as explaining the manner of death, and entombment of this particular specimen were discussed.

The facts relating to the dermal armor which now appear to be established from this preliminary study are: (1) That the armor of the neck, back, and tail was formed by two rows of erect plates, the elements of one row alternating with those of the other; (2) that the total number of plates in the two rows was not less than 20 and not more than 22; (3) that the position of the largest plate of the series appears to be above the base of the tail and not over the pelvis; (4) that the usual number of dermal spines on the tail is four arranged in two pairs.

*A microscopic study of sulfide ores of copper* (illustrated): L. C. GRATON. This paper is presented in full in the *Bi-monthly Bulletin of the American Institute of Mining Engineers.* 1913.

The 271st meeting of the Society was held in the Cosmos Club on May 14, 1913.

*Reconnaissance of the Lower Fraser River, B. C.*: N. L. BOWEN. The speaker examined the region bordering on the Fraser River from Lytton to Vancouver, British Columbia, during the summer of 1912, for the Geological Survey of Canada. The section crosses the Coast-Cascade uplift. The oldest rocks are highly disturbed argillites and quartzites with thin beds of limestone and associated volcanic rocks which are correlated on lithologic grounds with the Cache Creek group of Pennsylvanian age. With these are infolded a series of banded gray argillites which have yielded a single Mesozoic fossil and which are considered probably Jurassic. These latter have formerly been described by G. M. Dawson under the name Boston Bar group and tho he considered them probably Palaeozoic, the name is retained. Both of these earlier series strike, as a rule, northwestward and commonly have high dips. They have been invaded by Upper Jurassic granites which are generally somewhat sheared and in places have become typical gneiss. On the western flank of the Coast Range, near Agassiz and Chilliwack, occurs a sedimentary series which is probably also Jurassic, tho much less metamorphosed than its supposed eastern equivalent (Boston Bar group). The beds have yielded only indefinite Mesozoic fossils. The chief rock types are conglomerate, argillite, usually black, and limestone with a possible basal member of quartz porphyry. The strikes are northeastward, a rather unusual strike in the Cordillera.

Lower Cretaceous rocks, characterized by a moderate degree of disturbance, occupy a down-faulted belt running roughly parallel to the valleys of Fraser and Anderson rivers. The structure within the belt is synclinal. The rocks are dominantly clastic; arkose, argillite, and conglomerate making up the group, locally termed the Jackass Mountain group. Later batholithic rocks, provably Upper Cretaceous, occupy a wide belt near Hope and Agassiz. They differ from the Jurassic granites in being fresh and unsheared, and the dominant types are granodiorite, quartz diorite, and diorite with a later alkaline granite probably separated from the other types by a considerable time interval. The Jurassic and the Cretaceous batholiths make up the Coast Batholith. The Eocene beds of the Puget group occurring in the lower courses of the Fraser are clearly younger than all the rocks heretofore mentioned including the later batholiths. They are slightly disturbed and consist, on the whole, of little indurated beds of sandstone, conglomerate, and shale, presumably of estuarine character. The whole region with the exception of the higher peaks was covered with the Cordilleran ice sheet.

*Some special features of the glaciation of the Catskill Mountains:* H. E. MERWIN. Many of the rounded peaks of the Catskills reach heights

of nearly 4000 feet above the sea and above the Hudson-Mohawk lowland east and north. Glacial striae have been found on the tops of some of these peaks, but the peak farthest south, Slide Mountain, altitude 4200, is covered with loose residual gravel. The Catskills are unique in having several long deep valleys trending across the path of the main ice movement. These head in the bold escarpment above the Hudson valley, and drain westward. From their heads passes open about 2000 feet above the Hudson valley. During the period of ice retreat tongues of ice from the lobe in the Hudson valley flowed thru the passes down the valleys producing deposits which simulate accumulations from local glaciers. In hollows between spurs on the north sides of some of the peaks masses of ice entering from the north seem to have been cut off. Against these stagnant masses, yearly advances of the main ice tongues made deposits which are now barriers between the spurs.

*The present attitude of German geographers toward W. M. Davis' explanatory description of land forms:* François E. Matthes. (No abstract.)

Ralph W. Richards, *Secretary.*

## ANNOUNCEMENT OF MEETINGS

### CHEMICAL SOCIETY OF WASHINGTON

(Local Section American Chemical Society)

The 233d meeting will be a special meeting, to be held at the Cosmos Club at 8.15 p. m., Monday, December 22. Professor Earl B. Phelps, of the Hygienic Laboratory will lecture on "Recent Advances in Sewage Chemistry."

Robert B. Sosman, *Secretary.*

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## THE PROCEEDINGS

### OF THE

# WASHINGTON ACADEMY OF SCIENCES

There were printed, from 1898 to the discontinuance of the series in 1911, thirteen volumes of the Proceedings of the Washington Academy of Sciences. The Proceedings consist of original papers, covering a variety of subjects. The volumes contain from 200 to 700 pages and separates of each paper, to a limited number, are also available. A list of the titles with prices will be furnished on request by the Treasurer of the Academy, Mr. Alfred H. Brooks, Geological Survey, Washington, D. C., by William Wesley & Son, 28 Essex Street, Strand, London, or Mayer and Müller, Prinz Louis-Ferdinand Str., Berlin.

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